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ANNALS OF AGRICULTURAL RESEARCH

(Organ of the Indian Society of Agricultural Science)

To promote inter-disciplinary research in the field of agriculture and provide a forum for expressing views on policies and programmes relating to agricultural development

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IDENTIFICATION OF MORPHO-PHYSIOLOGICAL TRAITS FOR EXCESS SOIL MOISTURE TOLERANCE IN MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Large number of maize genotypes, having different origin (indigenous/exotic) and genetic backgrounds were screened under field conditions against waterlogging stress. The first and immediate injury symptom due to the stress was leaf yellowing/burning, which started from the base (older leaves) and proceed d towards the tip of the plants. Waterlogging stress, in general suppressed plant growth and development (stunted growth), dry matter accumulation, leaf area development, stomatal conductance, severely affected biochemical parameters such as chlorophyll, total soluble sugar and starch content in leaves etc., impaired anthesis-silking interval (ASI) and finally resulted poor kernel development and very poor yield.

Key words : *Zea mays*, excess moisture, morpho-physiological traits.

Excess soil moisture or a high water table due to excessive rainfall and/or inadequate drainage, is one of the most important constraints for maize production and productivity in Asian region. In India, excess soil moisture is a serious threat, where about 8.5 m ha of arable land is in grip of excess soil moisture situations of the total 6.2 m ha area of maize about 2.5 m ha is affected by this problem, which causes on an average 25-30% loss of national maize production, every year.

Though, maize crop has capacity to produce adventitious roots and possess morphological adaptations such as air spaces (arenchyma) in nodal root tissues during excess soil moisture period (Rathore *et al.*, 1996). However, flooding or excess soil moisture in maize generally seems to be most detrimental when it occurs during early growth stages. The identification and development of genotypes capable of withstanding the stress condition could be an ideal and affordable approach, suitable for poor maize-growing farmers. In past, several studies have been undertaken to study the impact of excess soil moisture on maize and to understand the basic mechanism behind the tolerant/susceptible reaction. Zaidi and Singh, 2001), the promising morpho-physiological traits associated with excess soil moisture tolerance in maize is yet to be identified. In view of this, the present investigation was undertaken to quantify the impact of the excess soil moisture stress and to identify the morpho-physiological traits(s) associated with the stress tolerance/susceptibility.

MATERIALS AND METHODS

The experiment was conducted in field conditions at the Maize Research Farm, Indian Agricultural Research Institute during Kharif seasons of 1999 and 2000. Seed of released maize inbred lines namely- CML-311, CML-327, CML-94, CM-500 and P501 c1#-500 was obtained from Winter Maize Nursery, Amberpet, Hyderabad. Planting was done in the third week of June, two seed per hill in flat field conditions with a row length of 2.5 m (5 rows of each genotype) and row-to -row distance 0.75m in three replications, each for normal and excess soil moisture conditions. Recommended dose of fertilizer (NPK, 120:80:60 kg/ha) was applied at the time of sowing and half of the nitrogen at vegetative stage as side dressing. One set of each genotype with three replicates was exposed to excess soil moisture treatment at knee-high stage (25-35 DAS, depending upon genotype). The treatment was applied in a way that basal portion of the plants (4-5 cm) is inundated in the stagnant water continuously for seven days.

All the plant growth and biochemical parameters were analyzed immediately after the stress treatment, except stomatal conductance that was recorded last day of the stress treatment. Stomatal conductance of uppermost fully expended leaf was measured using Infrared gas analyzer (LICOR Model 6400). Dry matter production was estimated on the above ground parts only. Five days after the stress treatment leaf chlorosis/necrosis was observed on visual score basis using 1-10 scale. Leaf area of green and fully matured leaves was measured with the help of automatic leaf area meter (LICOR-Model 3100). Plant mortality percentage was estimated at the time of flowering on the basis of earlier plant count made before the stress treatment. Chlorophyll, sugar and starch content in leaf were analyzed by sampling immediately after the excess soil moisture treatment.

At flowering stage, anthesis and silking were recorded. Kernel number and yield plant^{-1} were analyzed at the time of final harvest. A.S.I. (anthesis-silking interval) was estimated by calculating the difference between days to 50% anthesis and 50% silking. All the were statistically analyzed by using randomized block design. Data presented are average of the two years and mean value of three replications.

RESULTS AND DISCUSSION

Plant growth and development :

Leaf chlorosis was one of the first visible injury symptoms caused by excess soil moisture stress, initiated from the base and proceeded towards the top of the plants. The leaf yellowing was most severe in case of P501 c1 #-500, followed by CML-94. The impact was relatively negligible on CM-500, CML-327 and CML-311. The second most important visible injury symptom was stunted plant growth. The plant height was severely arrested in P501 c1#-500 and CML-94. It was observed that increase in plant height was almost stopped in these genotypes. Leaf area plant^{-1} significantly reduced due to the excess soil moisture (Table 1). The effect was more severe on

CML-94 (61.6%) followed by P501 c1#-500 (59.4%). On the other hand, the effect was comparatively less on CML-311 (7.48%) followed by CML-327 (11.54%) and CM-500 (13.3%). Data on total dry weight of above ground plant parts clearly revealed that the excess soil moisture treatment significantly affected dry matter production in all the genotypes studied. Among the genotypes, CM-500 recorded highest total dry weight, while minimum dry weight was recorded with P501 c1#-500, under normal and excess soil moisture conditions, respectively. Maximum reduction in total dry weight was noticed in CML-94 (62.06%) followed by P501 c1#-500, under normal and excess soil moisture conditions, respectively.

Stomatal conductivity, measured during excess soil moisture situation, declined significantly in most of the genotypes (Table 1). However, the impact was more prevalent in case of P501 c1#-500 and CML-94. The impact was comparatively nominal on CML-327. On the other hand, the stomatal conductance was increased due to stress condition in CML-311. Plant mortality, observed at the time of flowering, clearly depicts the severe impact of excess soil moisture stress on maize genotypes (Table 2). Though, there was some nominal losses under control condition also, however, the stress condition reduced the plant population even more than half in P501 c1#-500 followed by CML-94. On the other hand, the impact was negligible on CML-311, CML-327 and CM-500.

Biochemical compositions:

Data presented in Table 1 clearly revealed that excess soil moisture condition significantly affected total chlorophyll content in all the genotypes. However, there was remarkable genetic variability. Maximum chlorophyll content was found in CM-500, whereas, minimum was observed with CML-94 under both normal and excess soil moisture conditions. Severe

Table 1. Effect of excess soil moisture at knee high stage biochemical composition and stomatal conductance in maize genotype

Genotypes	Total chlorophyll (mg g^{-1})		Total soluble sugar (mg g^{-1})		Starch content (mg g^{-1})		Stomatal conductance (μ mol. Cm^{-2} s^{-1}	
	E	ESM	C	ESM	C	ESM	C	ESM
CML-94	1.07	0.74	87.03	57.42	119.01	86.36	120.43	113.12
P501 c1#-500	1.18	0.82	77.19	44.63	99.25	45.90	101.42	114.23
CM-500	1.39	1.25	91.23	80.72	115.23	90.21	115.08	90.04
CML-311	1.26	1.16	96.45	83.12	111.92	88.60	105.52	88.51
CML-327	1.38	1.23	90.12	84.30	100.90	79.60	104.31	98.08
L.S.D. (p=0.05)	G=0.012, M=0.009, GXM=0.021		G=4.63, M=4.12 GXM=7.45		G=9.89, M=8.91, GXM=17.05		G=NS, M=10.08 GXM=20.98	

inhibition of total chlorophyll was recorded in CML-94 (30.84%) and P501 c1#-500 (30.50%). The minimum inhibition was noted CML-311 (7.93%) followed by CML-327 (10.86%). Yan et a. (1996) also observed that seven days excess soil moisture at four leaf stage caused significant increase in chlorophyll breakdown in maize.

Data on sugar accumulation indicate that excess soil moisture condition, in general, reduced the soluble sugar content in leaf tissues, in case of all the genotypes (Table 1). Data on starch content (Table 1) clearly showed that, in general, excess soil moisture condition reduced starch content in all the genotypes. However, the effect was comparatively least on stem and severe on leaf starch content. The finding suggest that high sugar accumulating genotypes under normal condition and ability to maintain the content under stress conditions, may be a desirable attribute for excess soil moisture tolerance in maize. Similar observation has also been made by Schluter *et al.* (1996). Reduction in soluble CHO content under flooding may be possible due to leakage of the carbohydrate from tissue due to partial loss of membrane integrity (Gadallah, 1995; Yan *et al.* 1996) or increased consumption of stored carbohydrate due to arrested current photosynthetic activity (Palada and Vargara, 1972). Positive correlation between carbohydrate content and survival/tolerance during excess soil moisture condition have been suggested by a number of researchers (Palada and Vargara, 1972; Singh *et al.* 1998). Analogous to total soluble sugar, starch content in leaf was also affected severely due to excess soil moisture and increased utilization of existing starch content in maintenance respiration. Degradation of starch during excess soil moisture is a crucial biochemical event, which affects survival and growth of plants under the stressful situation. Genotypes such as P501 c1#-500 an CML-94 showed severe reduction in starch content, whereas the inhibition was comparatively less in CM-500, CML-311 and CM-327. High decrease in starch content coincided with a marked increased in amylolytic activity and low recovery after release of the stress. The genotypes having high starch content under normal condition and maintained the concentration under stressful condition also showed less injury and quick recovery growth after release of the stress (Singh *et al.*, 1998)

Yield and yield attributes :

Data on anthesis-silking interval (ASI) is presented in Table 2. Under normal conditions it was <5.0 days of all the genotypes. Excess soil moisture condition severely affected the ASI. Under the stress condition it varies from 1.7 days (CML-311) to infinitive (in the genotypes such as whenever ASI was more than 5.0 days it has affected the plant yield potential. Even 6.7 days (CM-500) ASI had shown inhibitory effects both on kernel number and grain yield. Data on kernel number plant-1 clearly indicate that it was directly correlated with ASI (Table 2). Delayed silking resulted high ASI and thereby no grain formation. Number of kernel per plant was highest in CML-327 where ASI was 2.3 days, under excess soil moisture conditions. Though, under normal condition there was no any direct relation between ASI and grain yield but under excess soil moisture condition the ASI (>5.0 days) was directly related to grain

Table 2. Effect of excess soil moisture on plant mortality (%), anthesis-silking interval, and kernel number ear^{-1} and grain yield in different maize genotypes

Genotypes	Plant mortality (%)		A.S.I. (days)		Kernel No. ear-1		Grain yield (kg/ha)	
	C	ESM	C	ESM	C	ESM	C	ESM
CML-94	2.8	48.3	2.0	-	109.0	0.0	2016	0.0
P501 c1#-500	4.8	65.3	4.0	-	93.7	0.0	1654	0.0
CM-500	2.3	10.3	1.0	6.7	205.0	93.7	4454	3356
CML-311	2.0	5.6	1.0	1.7	222.7	204.3	2698	2463
CML-327	1.8	9.6	0.0	2.3	238.7	211.3	2558	2389
L.S.D. (p=0.05)	G=NS, M=0.031 GXM=0.053		G=NS, M=0.11 GXM=0.19		G=5.62, M=4.39 GXM=8.94		G=11.67 M=9.83 GXM=20.28	

yield plant^{-1}. In case of <5.0 days of ASI was no relation, but as ASI crossed 5.0 days it directly affected kernel number plant^{-1} and thereby grain yield.

Susceptibility/tolerance ability of different genotypes was finally expressed during reproductive phase. Excess soil moisture situation delayed anthesis and silk emergence phenomenon in all the genotypes. However, there was a high degree of genetic variability. In general, silking was much more susceptible to the stress than anthesis (Zaidi, 2001). The influence of the stress on pollen shedding and silk emergence finally affected anthesis-silking interval. In normal conditions ASI was <5 days in almost all the genotypes (Table 2). On the other hand, it ranged from 1.7 days (CML-311) to infinitive (in the some genotypes such as - CML-94 and P501 c1#-500, where there no silking at all), under excess soil moisture situation. Similar observation has been made by Rathore *et al.* (1996). The process, ranges from silk premodia formation to silk emergence, was found to be largely dependent on availability of photosynthates (current source and/or temporary storage source through remobilization) as observed under drought condition in maize genotypes (Balonas and Edmeades, 1996). The excess soil moisture condition suppressed current photosynthesis and insufficient availability /slow remobilization of pre-anthesis photosynthates (Chingyuh *et al.*, 1996) may have resulted less than sufficient availability of assimilates for silk emergence. The scarcity of assimilates at the onset of female flowering may have delayed the effective silking which resulted long ASI and therefore, no pollination and fertilization. In these genotype there was no kernel formation (Table 2) and, therefore, zero yield. Interestingly, the ASI have been found to play a vital role in kernel development and grain yield. It was observed under normal situation that where ASI was <5.0 days, there was no direct relation with yield. However, under excess soil moisture situations, as and when ASI goes beyond

5.0 days, it affected the kernel number plant^{-1} and finally grain yield (Table 2). In case of tolerant genotypes such as CM-500, CML-311 and CML-327 where ASI was <5 days, though yield was declined under the stress condition, but it may be due to some other reasons and not related of ASI. In these genotypes impact of the stress condition was insignificant on ASI and kernel number plant^{-1}.

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NUTRIENT UTILIZATION EFFICIENCY OF RICE INFLUENCED BY DIFFERENT SOURCES AND LEVELS OF PHOSPHORUS AND RATES OF ZINC

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ABSTRACT

Field experiments were conducted at college farm, Institute of Agricultural Sciences, BHU, Varanasi, on a sandy clay loam soil during kharif 1993 and 1994 to find out the utilization pattern of phosphorus levels and sources and zinc rates by rice crop in terms of recovery factor, physiological and agronomic efficiency. It was observed that at a constant P-level i.e. 60 kg P_2O_5/ha, the highest agronomic efficiency was obtained with ammonium poly phosphate followed by urea nitric phosphate and diammonium phosphate. Lowest level of P 30 Kg P_2O_5/ha application recorded the highest agronomic efficiency. The same trend was also noticed in respect of zinc application. The highest physiological efficiency was recorded with 30kg P_2O_5/ha in the firm of di ammonium phosphate. While it was increased with increasing rates of zinc, The trend of apparent recovery(%) was similar as that of agronomic efficiency in respect of sources and levels of Phosphorous and rates of Zinc tested.

Key words : Rice, phosphorus zinc.

In India rice is the prime cereal crop occupying an area of 42 m. ha. with a production of 56 million tones. and contributing to nearly 42% of India's food grain production. However, the productivity of rice has stagnated all over the country. Therefore, it has become necessary to search for an approach where in efficiency of applied fertilizers could be increased by testing new fertilizer products like ammonium poly phosphate and urea nitric phosphate. In view of this, the present investigation was undertaken to study the effect of phosphatic carriers in conjunction with zinc on Zn deficient soil.

MATERIALS AND METHODS

A field experiment was conducted at college farm, Institute of Agricultural sciences, Banaras Hindu University (BHU), Varanasi during kharif seasons of 1993 and 1994 on sandy clay loam soil with pH 7.3, available N 254, available P_2O_5 20, available K_2O 325 kg/ha and Zn (dithiozone extractable) 0.6 ppm. The experiment was laid out in a 3^3 partially confounded design replicated twice. The treatment consisted

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of combinations of 3 sources. (ammonium polyphosphate (APP), urea nitric phosphate (UNP) and di-ammonium phosphate (DAP) and 3 levels of phosphorous (30, 60 and 90 kg P_2O_5/ha) and 3 rates of zinc (15, 30 and 45 kg $ZnSO_4$/ha) in addition to one control. Thus making 27 + 1 treatment combinations.

A common dose of 120 kg N + 60 kg K_2O/ha was applied. Half of the nitrogen, entire phosphorous as per treatments, entire potassium and zinc as per treatments were applied as basal dose at the time of puddling. Remaining half of the nitrogen was applied in two equal splits at 30 and 60 days after transplanting rice. The crop was transplanted on 4.8.93 and 30.7.94 and harvested on 12.11.93 and 8.11.94 in the 1st and 2nd year, respectively. Adopting a spacing of 20x10 cm, test variety, 'Sarjoo-52' was used. The nutrient utilization of applied P and zn in grain was studied in terms of recovery factor (a measure of the amount of nutrient taken up by the plant per unit amount of nutrient applied), physiological efficiency (raio between the grain produced and the nutrient absorbed) and the agronomic efficiency (a ratio between the amount of grain produced and the amount of nutrient applied). The P and Zn contents were estimated as per Jackson (1973) and Lindsay an Norvell (1978), respectively.

RESULTIS AND DISCUSSION

Effect of sources of phosphorous

The sources of phosphorus significantly influenced the grain yield, P uptake during both the years of study (Table 2). The APP recorded the highest grain yield than UNP and DAP which remained at par with each other during both years, though UNP recorded more grain yield over DAP. Similar trend of response was noticed in respect of Zn uptake. Whereas APP recorded the highest P uptake over UNP, DAP which also differed significantly between themselves. The higher grain yield and nutrient uptake obtained with APP source might be due to lesser fixation, slow hydrolysis and direct absorption (Tisdale *et. al.*, 1995) and action on plant metabolism possibly through a micro nutrient nutrition resulting from chelating properties (Rama Rao *et al.*, 1992).

APP recorded significantly higher agronomic efficiency and apparent recovery of phosphorus over UNP and DAP (Table 2) which were differed significantly during both the years, while the physiological efficiency of phosphorous was maximum with DAP followed by APP and UNP sources. The results are in conformity with the findings reported by Venugopalan and Prasad (1992).

Effect of levels of phosphorous

Phosphorous levels significantly increased the grain yield, phosphorous and zinc uptake during both the years. There was a significant and progressive increase in grain and pooled yield with successive increase in P levels from 30 to 90 kg P_2O_5/ha. Significant increase in uptake was observed up to 60 kg P_2O_5/ha only during both the years. Increasing P levels significantly increased the Zn uptake during both the years except second year in which Zn uptake obtained with 90 kg P_2O_5/ha was on par with 60 kg P_2O_5/ha. An adequate supply of P in the soil might have favoured the efficient use of P which in turn brought about higher grain yield. The results corrobate with the findings reported by Rama Rao *et al.* (1992) and Raju *et al* (1992).

Increase in P levels up to 90 kg P_2O_5/ha resulted in a decrease in agronomic efficiency and apparent recovery factor during both the years of study while the physiological efficiency of P was maximum with 30 kg P_2O_5/ha followed by 90 and 60 kg P_2O_5/ha (Table 2) which indicated that with higher levels of P application, the absorbed P was not efficiently utilized for grain production as at lower levels of it. Venugopalan and Prasad (1992) also reported the similar findings.

Effect of zinc Levels

Zinc application up to 30 kg Zn SO_4/ha significantly increased the grain yield , P and Zn uptakes during both the years of study, whereas 45 kg $ZnSO_4$/ha (Table 1), which indicated no beneficial effect of 45 kg Zn SO_4/ha in both the years. Control plot produced the lowest grain yield than

Table 1. Effect of different trsources and levels of P and rates of Zn application on grain yield and uptake o P and Zn

Treatment	Grain yield (g/ha)			uptake (kg/ha)		Zn uptake (kg/ha)	
	1993	1994	Pooled	1993	1994	1993	1994
P- Sources							
APP	46.02	44.04	45.03	38.67	38.31	0.40	0.40
UNP	43.53	43.15	43.34	34.12	33.37	0.35	0.36
DAP	42.01	42.37	42.19	25.00	25.28	0.32	0.34
C.D. at 5%	3.18	1.51	0.75	6.39	5.63	0.03	0.03
P-Levels (kg P_2O_5/ha)							
30	40.46	41.09	40.78	24.04	22.38	0.30	0.30
60	43.73	43.73	43.73	34.82	36.27	0.37	0.39
90	47.37	44.74	46.06	38.92	38.27	0.40	0.40
C.D. at 5%	3.18	1.51	0.75	6.39	5.63	0.03	0.03
Zn - RATES Levels							
15	41.26	41.31	41.28	28.14	26.94	0.31	0.32
30	44.76	44.36	44.56	35.42	35.60	0.38	0.38
45	45.55	43.9	44.72	34.21	34.41	0.38	0.38
C.D. at 5%	3.18	1.51	0.75	6.39	5.63	0.03	0.03
Control	33.16	36.35	34.76	10.88	11.83	0.14	0.15
C.D. at 5%	4.11	1.95	0.96	8.07	7.11	0.04	0.04
C Control vs Treated)							

the treated plots. The balanced supply of zinc up to 30 kg Zn So_4/ha in the soil might have favoured the efficient use of P and Zn by the rice crop. The present results coincide with the findings of Paramasivam *et.al* (1992). None of the interactions had a marked influence on grain yield and nutrient uptake of P and Zn during both the years of study.

During both the years, the agronomic efficiency of applied Zn was high at lower levels of Zn i.e. 15 kg $ZnSo_4$/ha and it was gradually decreased with increase in Zn levels up to 45 kg $ZnSo_4$/ha (Table 3). The

Table 2. Effect of sources and levels of phosphorus on apparent recovery (AR) physiological efficiency (PE) and agronomic efficiency (AE)

Treatment	Agronomic efficiency (kg grain/kg P_2O_5 applied)			Physiological efficiency (kg grain / kg P absorbed)			Apparent recovery (%)		
	1993	1994	Pooled	1993	1994	Pooled	1993	1994	Pooled
P- Sources (at 60 kg P_2O_5/ha									
APP	21.4	12.8	17.1	87	66	76.5	24.5	19.3	21.9
UNP	17.3	11.3	14.3	82	66	74.0	21.2	17.1	19.2
DAP	14.8	10.3	12.4	111	95	103.0	13.2	10.6	11.9
C.D. at 5%	2.4	1.0	1.5	9	7	8.8	3.4	2.6	3.0
P-levels (kg P_2O_5/ha)									
30	24.3	15.8	20.1	100	96	98.0	24.3	16.4	20.3
60	17.6	12.3	15.0	81	66	73.5	21.7	18.6	20.2
90	15.8	9.3	12.6	94	70	82.0	16.7	13.4	15.0
C.D. at 5%	2.4	1.0	1.5	9	7	8.8	3.4	2.6	3.0

Table 3. Effect of zinc on agronomic efficiency (AE), physiological efficiency (P.E) and apparent reccovery (AR) of Zn on rice

Treatment	Agronomic efficiency (kg grain/ kg P_2O_5 applied)			Physiological efficiency (kg grain / $ZnSo_4$/ absorbed)			Apparent recovery (%)		
	1993	1994	Pooled	1993	1994	Pooled	1993	1994	Pooled
Zn rates									
15	54.0	33.1	43.6	1012	709	860	0.53	0.47	0.50
30	38.7	26.7	32.7	1055	890	972	0.37	0.30	0.34
45	27.5	16.8	22.2	1126	839	983	0.37	0.30	0.34
C.D. at 5%	8.0	4.9	6.6	64	60	36	NS	NS	NS

physiological efficiency during both the years significantly increased with increasing levels of Zn from 15 kg to 45 kg $ZnSO_4$/ha. Increase in levels of Zn up to 30 kg $ZnSO_4$/ha resulted in a decrease in pparent recovery of zinc progressively during both the years and the differences in it due to varying rates of zinc did not attain the level of significance statistically. Venugopalan and Pradad (1992) also reported the similar findings.

Thus it is obvious that the nutrient utilization efficiency of rice crop was more when it was supplied with 60 kg P_2O_5/ha through APP in combination with 30 kg $ZnSO_4$/ha.

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INTERACTION EFFECT OF PHOSPHORUS, SULPHUR AND PSB INOCULATION ON GROWTH, YIELD AND NUTRIENT UPTAKE OF WHEAT

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ABSTRACT

The increasing levels of phosphorus and sulphur up to 60 kg ha significantly increased the plant height, dry mater accumulation, number of tillers, chlorophyll content effective tillers, number of grains per ear, test weight, seed yield, straw yield and protein content in seed. Nitrogen phosphorus and sulphur content in seed and straw and their uptake, net return and B:C ratio were also significantly higher with the application of P and S at 60 kg/ha. The inoculation of seed with PSB significantly enhanced all the growth and yield attributes, grain and straw yield, protein content in seed, nitrogen, phosphorus sulphur content in seed and straw and their uptake.

Key words : Wheat, interaction effect, phosphorus, sulphur, PSB inoculation.

Wheat being a major food crop of India, is a subject of great interest and concern also. The enormous pressure to produce more food from less land with shrinking natural resources is a tough task. This calls for special efforts to manage the key inputs without eroding the ecological assets and sound knowledge base to increase agricultural productivity on sustainable basis. The Indian soils are generally low to medium in available phosphorus and not more than 30 percent of applied phosphate is available to current crop, and the remaining part gets converted in to relatively unavailable forms. Use of sulphur free fertilizer in intensively cropped area, depletion of organic matter in soil which is supposed to be reservoir of sulphur are important causes for sulphur deficiency. The application of phosphorus and sulphur creats favourable environment and increases roman uptake of nutrients from soil for better growth and development (*Marok and Dev,* 1980). The inoculation of seed with PSB culture plays a vital role in solubilization of various insoluble inorganic and organic phosphates added to the soil as phosphat is fertilizers.

MATERIALS AND METHODS

A field experiment was conducted at experimental farm of S.K.N. College of Agriculture, Jobner during *rabi* 1999-2000. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.23 percent), low in nitrogen (140.50 kg/ha), medium in available P (18.60 kg/ha) and potash (148. 65 kg/ha) and sulphur (0.0014%). The treatment comprising three levels of phosphorus (20, 40, and 60 kg P_2O_5/ha), three levels of sulphur (0.30 and 6 kg S/ha) and two levels of PSB inoculation (no inoculation and seed inoculation) were replicated thrice in a factorial randomized block design. Phosphorus as per treatments was drilled manually in the firm of DAP prior to sowing at a depth of 10 cm in furrows, sulphur was applied gypsum as per treatments before sowing and incorporated in soil and PSB inoculation was done to wheat seed (variety 'Raj. 3077') and was sown on 30 November 1999 using "Kera" method at a depth of 5 cm in rows spaced at 22.5 cm apart.

RESULTS AND DISCUSSION

Growth

Irrespective of the levels of sulphur, increasing levels of phosphorus application increased the plant height, dry matter accumulation, number of tillers per meter row length and chlorophyll content significantly. Similarly, irrespective of the levels of phosphorus, the increasing levels of sulphur application increased the plant height, dry matter accumulation, number of tillers per meter row length and chlorophyll content at flag leaf stage significantly (Table 1). The combined spplication of 60 kg P_2O_5 ha + 60 kg S/ha recorded significantly migher plant height, dry matter accumulation, number of tillers per meter row length and chlorophyll content at flag leaf stage over rest of the combinations of phosphorus and sulphur. It is attributed to favourable environment by sulphur application in the rhizosphere by reducing the soil pH leading to higher nutrient availability and uptake. Their effect was complementary to each other and synergistic up to certain levels in promoting the growth of the crop plants.

Yield

Irrespective of levels of sulphur, the application of increasing levels of phosphorus increase the effective tillers per meter row length, grains per ear, test weight and straw yield significantly (Table 2). Similarly irrespective of the level of phosphorus, the higher number of effective tillers, number of grains per ear, test weight and straw yield significantly with increasing levels of sulphur. The overall maximum effective tillers number of grains per ear, test weight and straw yield were observed under combined application of 60 kg P_2O_5 + 60 kg S/ha as compared to all other combinations of phosphorus and sulphur. The application of phosphorus helped in vigorous root development and proliferation, increased nodulation and N_2 fixation. The combined application of phosphorus and sulphur created favourable environment for growth and development (Rodrigue *et al.*, 1993).

Nutrient uptake

Both phosphorus and sulphur being the constituents of several metabolic compounds played an important role in photosynthesis, protein, carbohydrate and chlorophyll synthesis and biological energy transformations and thus influenced the

Table 1. Interaction effect of phosphorus and sulphur levels on plant height, dry matter accumulation, number of tillers and chlorophyll content of wheat

	Sulphur (kg/ha)											
Treatments	0	30	60	0	30	60	0	30	60	0	30	60
levels of P_2O_5 (kg/ha)	Plant height (cm)			DM accumulation (g) at harvest			No. of tillers/m row length harvest			Chlorophyll content (mg g-1 fresh leaf t.)		
20	85.53	87.36	89.03	210.76	214.69	214.45	126.64	127.41	127.88	2.24	2.42	2.60
40	88.42	90.78	93.78	214.81	217.28	219.69	127.71	132.55	137.25	2.40	2.91	3.26
60	88.61	93.21	96.52	215.08	220.11	224.69	130.77	136.25	138.05	2.52	3.40	3.43
C.D. at 5%		0.068			0.682			0.618			0.0399	

Table 2. Interaction effect of phosphorus and sulphur levels on number of effective tillers, grains per ear, test weight and straw yield of wheat

	Sulphur (kg/ha)											
Treatments	0	30	60	0	30	60	0	30	60	0	30	60
levels of P_2O_5 (kg/ha^{1})	No. of effective tiller at harvest			Grain per ear			Test weight (g)			Straw yield (q/ha)		
20	101.31	103.40	106.75	43.61	43.88	44.03	32.61	34.58	34.89	38.76	42.66	43.98
40	104.19	116.34	117.08	44.00	44.45	44.86	36.56	36.75	37.06	43.26	45.99	48.15
60	114.93	157.57	123.42	44.03	45.22	45.69	36.94	36.42	37.73	43.53	49.33	52.32
C.D. at 5%		0.399			0.121			0.644			0.653	

Table 3. Interaction effect of phosphorus and sulphur levels on protein (%) in grain, total N,P and S uptake of wheat

Treatments	Sulphur (kg/ha)											
	Protein in grain			N uptake g (kg/ha)			P uptake (kg/ha)			S uptake (kg/ha)		
levels of P_2O_5 (kg/ha)	0	30	60	0	30	60	0	30	60	0	30	60
20	9.206	10.872	10.893	57.740	72.107	77.802	16.378	18.624	19.762	10.465	13.289	13.962
40	11.009	11.509	12.353	76.024	92.004	103.337	19.623	24.324	26.032	13.230	14.658	15.681
60	11.509	11.925	12.562	81.752	102.422	114.727	20.040	29.852	32.075	13.56	16.062	17.435
C.D. at 5%		0.1365			0.4872			0.1645			0.452	

Table 4. Interaction effect of phosphorus levels and PSB inoculation on phosphorus content (%) in grain and phosphorus uptake

Treatments	PSB inoculation			
levels of P_2O_5	No inoculation (I_0)	Seed inoculation (I_i)	No inoculation (I_0)	Seed inoculation (I_i)
(kg/ha)	Phosphorus content (%) in grain		Phosphorus uptake (kg/ha)	
20	0.462	0.475	17.66	18.84
40	0.526	0.539	22.55	24.09
60	0.580	0.589	26.48	28.16
C.D. at 5%	0.0194		0.134	

plant growth. Their effect was complementary to each other and synergistic up to certain levels in increasing nitrogen and protein content of grain (Table 3). Both phosphorus and sulphur interacted each other and influenced the utilization. The synergistic effect of the these nutrients improved the overall nutritional environment in the whole plant system and enhanced plant growth by promoting the meristematic activity and dry matter accumulation. The significant interactive effect of phosphorus and sulphur on protein content might be due to higher nitrogen content of seed and straw. The uptake of nitrogen, phosphorus and sulphur were more under the highest dose of both these nutrients (60 kg P2O5 + 60 kg S/ha). These findings are in close conformity with Vyas *et al.* (1997).

Interaction effect of phosphorus and PSB inoculation

The inoculation of wheat seed with phosphate solubilizing bacteria led to significant increase in phosphorus content of wheat grain and total phosphorus uptake by wheat (Table 4). PSB plays a vital role in the solubilization of various insoluble inorganic and organic phosphates present in soil or added to the soil as phosphatic fertilizers. Production of organic acids by microorganisms appears to be the major factor involved, though other factors as protein extrusion mechanism, production of humic acid substances, H_2S, H_2SO_4, CO_2 and enzymes are also reported to play in the solubilisation of inorganic phosphate (Gaur, 1990).

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EFFECTIVENESS OF AFRICAN AND INDIAN ROCKPHOSPHATES ON RELATIVE AGRONOMIC EFFICIENCY AND PHOSPHORUS USE EFFICIENCY IN A TYPIC HAPLUDALF

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ABSTRACT

A field experiment was conducted during rabi 1995-96 and kharif to study the effect of different rockphosphates on relative agronomic efficiency (RAE), phosphorus use efficiency (PUE), response yardstick and B/C ratio of maize and wheat grown in an acid Alfisol. It was observed that relative agrnomic efficiency in both the crops was maximum in Gaffsa followed by Tebessa, Youssfia and MRP as compared with SSP. But, among rockphosphates, Gaffsa and Tebessa were definitely better than rest of the sources. In case of B/C ratio, the order of magnitude at wheat harvest was SSP>Tebessa>Gaffsa>MRP, but at maize harvest the trend was Gaffsa>Tebessa>SSP>Youssifia>MRP.

Key words : Wheat, maize, acid Alfisol, RAE, PUE, response,B/C ratio, rockphosphate.

Phosphorus is one of the major essential nutrient for plant growth and its deficient in acid soils. In India, out of the net cultivated area of 143 ,illion hectares, 49 million hectares are considered as acidic soils (Panda, 1990). In Himachal Pradesh, acid soils occupy about 25-30% of the net cultivated area (Bishnoi, 1979). These soils have high P fixing capacity, which render the P unavailable, released from soluble sources like SSP. Furthermore, due to rise in prices of these fertilizers, the alternative for the farmer is to use of cheaper source of P fertilizers like rockphosphates. These rock phosphates not only act as conditioner and amendment but also supply sufficient quantities of other nutrient elements such as Ca, Mg, Mn and Fe. The improved rocphosphates like African rockphosphates are high in grade and have good reactivity as compared to indigenous one. Very little work has been done on this aspect, therefore the present study was conducted to investigate the effect of different P sources in wheat - maize sequence.

MATERIALS AND METHODS

An experiment was conducted at the experimental farm of Deparrtment of soil Scinece, HPKV, Palampur having Typic haplundalf soil. The soil was acidic in reaction (pII 5.6) having silty clay loam texture. The content of organic carbon was 0.10 g/kg, available N P and K, 361, 20 and 316 Kg/ha, respectively. The CEC was 1.4 cmol (P^1)/kg and P-fixing capacity 600 mg/kg soil.

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This study was a part of the pre- established experiment which was started in *kharif* 1994.The present study shows the results of *rabi* 1995-96 wheat (4th crop) followed by maize during *kharif* 1996 (5th crop) in maize-wheat sequence started in Kharif 1994. There were eleven treattments *viz.* Control, Tebessa, Gaffsa, Youssofia and Mussoorie rockphosphate @ 250 and 500 kg P_2O_5 ha^{-1}, SSP @ 25 and 50 kg P_2O_5/ha, respectively. All the four rockphosphates were applied in one lot before the start of the experiment in *kharif* 1994 for ten crops, however, SSP was applied @ 25 and 50 kg P_2O_5/ha to each plot in each crop. The design of the experiment was randomised block design with three replications. Standard seed rate and spacing and N as wella s K dose were applied to each crop at proper time of application. Farmyard manure was applied @ 10 t/ha as basal both for wheat and maize in every plot. The sowing of wheat and maize was done on 23rd Nov., 1995 and 3rd June, 1996 and harvesting on 17th May, 1996 and 23rd September, 1996, respectively. In order to calculate the phosphorus use efficiency *(PUE)*, the P uptake by previous crops was also taken into consideration including the crops of the current study.

The PUE was calculated as follows:

$$PUE = \frac{\text{P uptake in treated plot (kg/ha)} - \text{P uptake in control plot (kg/ha)}}{\text{Rare of P applied (kg/ha)}} \times 100$$

The relative agronomic efficiency *(RAE)* was calculated ad follows:

$$RAE = \frac{Yt - Yc \times 100}{Ys - Yc}$$

Yt = Yield in treated plot

Ye = Yield in control plot

Ys= Yield standard i.e. SSP.

Response yardstick (kg grain kg^{-1} P_2O_5) was also calculated as follows :

Response of maize (kg grain/kg P_2O_5)

(Average of three crops) =

$$\frac{\text{Average grain yield upto kharif 1996- average grain yield in control up to kharif 1996}}{\text{Total amount of applied through given source}}$$

Response of wheat (kg grain/kg P_2O_5)

(Average of two crops) =

$$\frac{\text{Av. Grain yield upto rabi 1995-96 - Av. yield in control upto 1995-96}}{\text{Total amount of P applied through given source.}}$$

B/C ratio was worked out as indicated below

$$= \frac{\text{Cost of 1 kg grain*}}{\text{Cost of 1 kg } P_2O_5}$$

*GRain yield = grain yeild in treated plot - grain yield in control plot

RESULTS AND DISCUSSION

Relative agronomic efficiency

The relative agronomic efficiency in

wheat and maize was maximum in Gaffsa followed by Tebessa, Youssofia and MRP at both levels of P as well as in their main effects (Table 1) as compared to the standard SSP. The superiority of Gaffsa over rest of the sources may be attributed to the reason that it has maximum citrate solubility of P_2O_5 (24%) and molar ratio 0.285 (Khasawneh *et al,* 1980).

The relative agronomic efficiency was of higher magnitude at lower dose of P applied as compared to higher doses, where it was low except in case of MRP for wheat. This can be due to law of diminishing returns (Tisdale and Nelson, 1996).

Phosphorus use efficiency

The Phosphorus use efficiency has been worked out after the harvest of maize (5th Crop). The PUE through fertilizer source {F(P)} was higher in SSP as compared to other P sources (Table 2). Among different rock phosphates, Gaffsa and Tebessa were superior over Youssffia and MRP in recording PUE through fertilizer-P. The PUE at harvest of maize from fertilizer P was 31.54, 17.70, 17.63 12.72 and 7.7% in SSP, Gaffsa, Tebessa, Youssofia and MRP, respectively. The higher PUE in SSP might be due to readly available P and high P uptake as compared to other citrate soluble P sources. Among rockphosphates, the superiority of Gaffsa might be due to more reactive nature and more availability of P as already mentioned (Rajan *et al.,* 1996). There was minor increase in fertilizer PUE under higher P levels due to more P uptake as compared to lower dose. Mishra *et al.,* 1985 & Bahl and Pasricha, 1995 also reported similar results.

Response yardstick (kg grain/kg P_2O_5) and B/C ratio

A reference to Table 3 indicate that the response of P i.e kg grain produced/kg P_2O_5 applied was 5.03 and 5.42 in wheat and 12.34 and 10.43 in maize at 250 and 500 kg P_2O_5/ha, respectively. Consequently the levels did not influence the response yardstick.

Table 1. Effect of levels and sources of P on relative agronomic efficiency (%) of crops

	Levels (kg P_2O_5/ha)					
	Wheat			Maize		
Source	250	500	Mean	250	500	Mean
Tebessa	125.9	49.6	87.8	145.8	70.1	129.4
Gaffsa	163.0	65.9	114.4	174.6	85.0	129.8
Younssofia	63.0	43.9	53.4	86.4	50.3	68.4
MRP	25.9	33.3	29.6	71.2	45.5	58.4
*SSP**	100	100		100	100	

*In case of SSP, the dose were 25 and 50 kg P_2O_5/ha instead of 250 and 500 kg P_2O_5/ha as in rockphospate and it was kept standard. Detail is given in the material and method.

as compared to Youssofia and MRP, which as wheate solubility 15.1% and 1.4% and molar ratio 0.236 and 0.008 ( )

Table 2. Effect of levels and sources of P on phosphorus use efficiency through fertilizer source (%) at maize harvest

Source	Levels (kg P_2O_5/ha)		
	250	500	Mean
Tebessa	18.98	16.28	17.63
Gaffsa	20.00	15.40	17.70
Youssofia	12.65	12.79	12.72
MRP	10.70	10.84	10.77
*SSP** *(Standard)*	25.49	37.58	31.54
Mean	17.56	18.58	

Among different P sources, response was maximum in SSP and least in MRP in both the crops. Next to SSP, Gaffsa and Tebessa generated more response over Youssofia. The effect of P levels on B/C ratio did not differ in wheat, the value was 2.42 at both 250 and 500 kg P_2O_5 ha level. In maize, the values were 5.78 and 4.60 at 250 and 500 kg P2O5/ha level. The B/C ratio differed in different P sources in both crops. The order of magnitude of B/C rati at wheat harvest was as follows: SSP/ Tebessa>Gaffsa> Youssofia> MRP with its values 3.57, 2.66, 2.50, 1.80 and 1.58, respectively. The trend of B/C ratio in maize Gaffsa (6.46) followed by Tebessa (6.02), SSP (5.63), Youssofia (4.48) and MRP (3.06).

Table 3. Effect of levels and sources of P on the average (kg grain/kg P_2O_5 and B/C ratio

	Kg grain/kg P_2O_5						B/C ratio					
Source	Wheat (Av. of two years)			Maize (Av. of three yars)			Wheat (Av.of two years)			Maize (Av.of three years)		
Levels (kg P_2O_5/ha)	250	500	Mean	250	500	Mean	250	500	Mean	250	500	Mean
Tebessa	4.84	4.02	4.43	13.04	8.84	10.94	2.90	2.41	2.66	7.17	4.86	6.02
Gaffsa	4.96	3.36	4.16	13.24	9.26	11.24	2.98	2.02	2.50	7.82	5.09	6.46
Youssofia	2.68	3.34	3.01	8.20	8.08	8.14	1.61	2.00	1.80	4.51	4.44	4.48
MRP	2.68	2.56	2.62	6.96	5.28	6.12	1.61	1.54	1.58	3.83	2.90	3.06
*SSP**	10.0	13.8	11.9	20.24	20.68	20.46	3.60	4.14	3.57	5.57	5.69	5.63
Mean	5.03	5.42	-	12.34	10.43	-	2.42	2.42	-	5.78	4.60	-

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INFLUENCE OF THREE CARBAMATE PESTICIDES ON TRACE ELEMENT STATUS (BORON, COPPER AND COBALT) OF ALIGARH SOIL

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ABSTRACT

The effect of different doses of three carbamate pesticides on the change in concentration of water soluble boron, available copper, total copper and total cobalt over a period of 90 days is studied on saline sodic soil of Aligarh. Results revealed an optimum effect on the concentrations of B, Cu and Co with 0.25 g of pesticide I, 0.2 g of pesticide II and 0.3 g of pesticide III per kg of soil at an interval of 30 days of application. The trace element status then declined. In presence of pesticides, the pH decreases while Eh and EC increases with time upto 30 days of application. The results are explained on the basis of chemical and microbial activity of pesticides in soil. The activity of pesticides was in order II> I> III. The correlation coefficient data suggest similar mechanism of the variation of trace elements in soil.

Key words : Carbamate pesticides, soil, boron, copper, cobalt.

Soil harbours a dynamic population of micro-organisms. Their abundance in nature gives an indication of their possible role in decomposition of organic matter, humification of organic resudies etc. Carbamate pesticides are being widely used to increase the crop growth. The decomposition of pesticides by micro-organisms results in the more availability of nutrients viz., Fe, Mn, B, Cu, Co in soil (Patill and Varade, 1998).The type of organic matter added is the one of the most important factor which influences the extent of availability of nutrients in soil (Mukherjee *et al.* 1990; Debnath *et al.* 1994). Elements like boron, copper and cobalt play important role in plant metabolism and in animal nutrition or toxicity (Nason, 1958). Keeping the aforesaid points in view, an experiment was conducted to study the effect of three carbamate pesticides (I, II, III) on the status of boron, cobalt and copper and soil microbes of saline sodic soil of Aligarh at different time intervals.

MATERIALS AND METHODS

The physico-chemical properties of the soil (depth 0-30 cm) used in study were as follows pH = 8.4, EC 0.42 ds m^{-1} ; Eh = 40.2 mV, CEC 9.8 (Cmole (p^+) kg^{-1}); ESP = 21.5, organic carbon 0.64%; water soluble boron = 2.60 ppm; available copper = 1.64 ppm; total copper = 52.1ppm and total cobalt = 19.1 ppm.

The experiments were done in triplicate in earthenware pots (60 cm x 45 cm) lined with polyethylene sheet without any crop. Each plot was filled with 5 kg of soil, the soil was amended with seven levels (0.0, 0.1, 0.2, 0.25, 0.3, 0.4, 0.5 g kg^{-1} soil, t_0 to t_6) of three carbamate pesticides, 1. Oxamyl (Methyl N, N'-dimethyl-N-(methyl carbamoyl) oxythiooxamimidate); II. S-Ethyl-N-(methyl carbamoyl) oxythioacetamidate and III. N-Phenyl (1-ethyl carbamoyl) propylcarbamate separately. All the samples were then watered upto the water holding capacity with distilled water. The pots were then watered weekly throughout the course of experiment to make up for the loss of weight (due to evaporation) on standing.

The treated samples were drawn periodically by a soil sampler at intervals of 15 days and analysed spectrophotometerically for water soluble boron, available copper, total cobalt. Water soluble boron was determined by Gupta (1979) method available and total copper at 440 nm by cheng and Bray's carbamate (1953) method; and total cobalt at 530 nm by Sandell's (1994) method. The pH, EC, organic carbon were derermind by methods as discussed elsewhere (Singh *et al.* 1976). The values of redox potential (Eh) wee determined using platinum electrode by pH meter. Correlation coefficients were also calculated.

Bacterial fungal counts were estimated at different time intervals by serial dilution and planting technique. There were three replications in each case.

RESULTS AND DISCUSSION

The results indicate that application of different doses of three carbamate pesticides decreased (the pH from 8.40 to 7.95); Eh while increased from 40.2 to 48.5 mv) and (EC from 0.42 to 0.57 dS m^{-1}) at an interval of 30 days of application.

The population of fungi, bacteria and actinomycetes (Table 1) increased by addition of carbamate pesticides to soil upto 30 days of application and reached a maximum value with 0.25 g kg^{-1} of soil pesticide I; 0.2 g kg^{-1} of soil of pesticide II and 0.3 g kg^{-1} of soil of pesticide III and then declined with concentration and time.

The average of replicated values for water soluble B, available Cu, total Cu and total Co are recorded in Table 2 to 5. An examination of Table 2 indicates that in presence of three carbamate pesticides, as compared to control, the water soluble boron increased significantly, reached a maximum value with 0.25 g kg^{-1} soil for pesticide I; with 0.2g kg^{-1} soil for pesticide II and 0.3 g kg^{-1} soil for pesticide III at 30 days of its application and then declined. The dose order was $t_3 > t_2 > t_4 > t_1 > t_5 > t_6 > t_0$ for pesticide 1; $t_2 > t_3 > t_4 > t_1 > t_5 > t_0 > t_6$ for pesticide II and $t_4 > t_3 > t_2 > t_5 > t_1 > t_6 > t_0$ for pesticide III. The increase in water soluble boron upto 30 days of its application was due to its liberation from organic matter in a mineralised from by the stimulated activity of pesticide resistent bacteria which led to decomposition of organic matter as the soil was wetted with water (supported by pH and microbes data) (Ballal *et al.* 1961) (Table 1). The thiobacillus bacteria seemed to have played a notable role in the solubilisation of boron. The decline with passage of time appeared to be due to dissipation of chemical with re-establishment of boron fixing bacteria and adsorption of boron by soil minerals. These observations are in line with those of Wenseley (1953) and Martin (1957).

Table 1. Effect of carbamate pesticides on microbial population (F x 10° g^{-1} soil; Bx10° g-1 soil; A x 10^{6} g^{-1} soil) with variation in concentration and time

Organisms	Pesticide I							Pesticide II							Pesticide III						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_1	T_2	T_3	T_4	T_5	T_6	T_7
15 days																					
F	1.0	1.0	1.1	1.0	1.0	1.1	1.0	1.0	1.0	1.2	1.1	1.1	1.1	1.0	1.0	1.1	1.2	1.2	1.1	1.1	10
B	5.7	5.7	5.8	5.6	5.9	5.7	5.7	5.7	5.8	6.0	5.8	5.9	6.0	6.0	5.7	5.6	5.8	5.7	5.8	5.7	5.8
A	7.1	7.0	7.2	7.0	7.2	7.1	7.1	7.1	7.1	7.3	7.1	7.2	7.0	7.0	7.1	7.0	7.2	7.1	7.0	7.2	7.1
15 days																					
F	1.2	1.6	2.3	2.8	2.2	1.7	1.3	1.2	1.7	2.6	2.4	2.1	1.7	1.2	1.2	1.2	2.0	2.3	2.7	2.1	1.6
B	6.0	7.1	7.9	8.5	7.2	6.7	6.1	6.0	7.3	8.2	8.0	7.5	7.0	6.2	6.0	6.9	7.6	8.0	8.4	7.7	6.9
A	7.9	8.6	9.8	10.4	9.3	8.4	8.0	8.1	9.3	10.0	9.7	9.0	8.3	7.9	8.0	8.4	9.2	9.8	10.2	9.1	8.2
30 days																					
F	1.3	2.0	3.0	3.5	2.7	2.1	1.7	1.3	2.2	3.3	3.0	2.5	2.0	1.7	1.3	1.8	2.6	3.0	3.4	2.5	1.9
B	6.3	8.0	9.1	10.2	8.6	7.9	7.0	6.4	8.3	9.9	9.0	8.3	7.7	6.8	6.3	7.3	8.6	9.4	10.1	8.9	7.3
A	8.3	9.4	11.6	13.6	11.4	10.0	9.1	8.5	10.1	12.6	12.0	10.8	9.4	8.8	8.3	8.9	10.9	12.4	13.1	11.0	9.6
45 days																					
F	1.2	1.8	2.7	3.1	2.4	2.0	1.7	1.2	2.0	3.0	2.6	2.3	2.0	1.6	1.2	1.6	2.4	2.8	3.1	2.3	1.7
B	6.1	7.7	8.6	9.6	8.2	7.5	6.8	6.2	7.9	9.3	8.8	8.0	7.3	6.6	6.0	7.1	8.2	8.9	9.3	7.9	6.5
A	8.0	9.0	11.0	12.8	10.7	9.1	8.4	8.1	9.4	12.0	11.0	10.0	8.9	8.2	8.1	8.7	9.3	11.0	11.9	10.0	8.8
60 days																					
F	1.2	1.7	2.4	2.8	2.2	1.9	1.5	1.2	1.9	2.7	2.4	2.2	1.9	1.6	1.2	1.4	2.3	2.5	2.7	2.0	1.5
B	6.0	7.3	8.1	9.2	7.7	7.2	6.5	6.1	7.5	9.0	8.3	7.5	7.0	6.5	5.9	6.6	7.8	8.1	8.5	7.3	6.2
A	7.7	8.3	10.1	11.3	10.0	8.4	7.9	7.8	8.8	11.0	10.0	9.2	8.4	8.0	7.7	8.1	8.3	9.8	10.6	8.6	8.0
75 days																					
F	1.1	1.6	2.2	2.5	2.0	1.7	1.4	1.1	1.7	2.3	2.1	2.0	1.8	1.5	1.1	1.3	2.0	2.1	2.3	1.7	1.4
B	5.8	7.0	7.6	8.3	7.0	6.6	6.3	5.9	7.3	8.0	7.3	7.0	6.7	6.2	5.7	6.3	7.1	7.7	8.1	6.9	6.0
A	7.5	7.8	9.0	10.2	8.8	7.7	7.1	7.6	8.2	9.4	9.1	8.9	8.3	7.6	7.3	7.5	7.7	9.0	9.8	8.0	7.4
90 days																					
F	1.0	1.5	2.0	2.3	1.9	1.6	1.2	1.0	1.6	2.1	2.0	1.9	1.6	1.5	1.0	1.2	1.8	2.0	2.0	1.6	1.3
B	5.8	6.7	7.3	7.5	6.8	6.2	6.0	5.9	7.1	7.7	7.1	6.9	6.5	6.1	5.5	6.6	6.7	7.2	7.5	6.5	5.9
A	7.2	7.2	8.3	8.9	8.0	7.1	6.9	7.5	8.0	9.0	8.8	8.6	8.0	7.3	7.0	7.2	7.3	8.3	9.0	7.6	7.1

F= Fungi; B = Bacteria; A= Actinomycetes.

Table 2. Effect of carbamate pesticides on water soluble boron of soil with variation in concentration and time

Dose in g per kg of soil	Water soluble boron in ppm at various days							Average
	1	15	30	45	60	75	90	
				Oxamyl				
0.0	2.60	2.86	3.17	2.94	2.67	2.68	2.42	2.76
0.1	2.66	3.16	3.48	3.28	2.95	2.88	2.42	2.98
0.2	2.66	3.36	3.60	3.46	3.10	2.96	2.67	2.98
0.25	2.60	3.44	3.93	3.60	3.30	3.96	2.67	3.23
0.3	2.60	3.28	3.66	3.40	3.18	2.96	2.67	3.11
0.4	2.50	3.16	3.50	3.20	2.80	2.80	2.67	2.96
0.5	2.50	2.98	3.31	3.06	2.80	2.79	2.58	2.86
Average	2.60	3.18	3.51	3.28	2.97	2.88	2.59	
LSD for days	0.01							
LSD for doses	0.02							
				S-Ethyl-N-(methyl(carbamoyl oxy) thioacetimidate				
0.0	2.60	2.86	3.17	2.94	2.67	2.68	2.42	2.76
0.1	2.56	3.10	3.50	3.20	2.93	2.80	2.65	2.96
0.2	2.62	3.47	4.00	3.64	3.34	3.09	2.65	3.26
0.25	2.58	3.28	3.82	3.46	3.19	2.97	2.65	3.14
0.3	2.50	3.14	3.66	3.16	3.05	2.90	2.65	3.02
0.4	2.56	2.98	3.26	3.00	2.85	2.74	2.65	2.87
0.5	2.60	2.70	2.90	2.80	2.64	2.60	2.44	2.67
Average	2.58	2.94	3.46	3.17	2.95	2.82	2.59	
LSD for days	0.02							
LSD for doses	0.02							
				N-Phenyl-(ethyl carbamoyl) propyl carbamate				
0.0	2.60	2.70	2.80	2.90	2.70	2.64	2.42	2.68
0.1	2.61	2.96	3.34	3.13	2.88	2.75	2.59	2.89
0.2	2.64	3.36	3.80	3.56	3.24	3.00	2.75	3.19
0.25	2.69	3.51	3.99	3.67	3.34	3.11	2.75	3.30
0.3	2.72	3.74	4.26	3.88	3.54	3.28	2.75	3.46
0.4	2.66	3.16	3.66	3.15	3.00	2.88	2.65	3.02
0.5	2.60	2.86	3.12	2.90	2.80	2.70	2.65	2.80
Average	2.65	3.18	3.58	3.30	3.07	2.91	2.65	
LSD for days	0.02							
LSD for doses	0.02							

Table 3. Effect of carbamate pesticides on available copper of soil with variation in concentration and time

Dose in g per kg of soil	Available copper in ppm at various days							Average
	1	15	30	45	60	75	90	
				Oxamyl				
0.0	1.64	1.91	2.15	2.00	1.90	1.81	1.65	1.86
0.1	1.68	2.00	2.33	2.24	2.00	1.89	1.75	1.98
0.2	1.69	2.10	2.60	2.43	2.20	2.02	1.95	2.14
0.25	1.72	2.71	3.30	2.80	2.60	2.39	2.39	2.56
0.3	1.60	2.14	2.66	2.26	2.13	2.00	1.90	2.10
0.4	1.58	2.00	2.30	2.06	2.04	1.88	1.68	1.94
0.5	1.52	1.80	2.20	2.00	1.90	1.88	1.60	1.84
Average	1.52	2.10	2.51	2.26	2.11	1.98	1.84	
LSD for days	0.01							
LSD for doses	0.02							
				S-Ethyl-N-(methyl(carbamoyl oxy) thioacetimidate				
0.0	1.64	1.91	2.14	1.96	1.88	1.86	1.66	1.86
0.1	1.67	2.00	2.46	2.26	2.00	1.90	1.67	1.99
0.2	1.68	2.65	3.19	2.85	2.55	2.39	2.03	2.48
0.25	1.58	2.24	2.88	2.43	2.25	2.12	1.89	2.20
0.3	1.62	2.00	2.56	2.20	1.98	1.87	1.74	2.00
0.4	1.50	1.90	2.39	2.06	1.90	1.76	1.65	1.89
0.5	1.59	1.77	2.16	1.96	1.84	1.76	1.65	1.82
Average	1.62	2.07	2.54	2.24	2.05	1.94	1.75	
LSD for days	0.02							
LSD for doses	0.03							
				N-Phenyl-(ethyl carbamoyl) propyl carbamate				
0.0	1.64	1.71	1.90	1.74	1.66	1.62	1.59	1.69
0.1	1.65	1.80	2.12	1.90	1.74	1.70	1.62	1.79
0.2	1.65	1.92	2.31	2.05	1.90	1.80	1.68	1.89
0.25	1.62	2.05	2.58	2.17	2.00	1.90	1.75	2.01
0.3	1.65	2.10	2.72	2.28	2.14	2.00	1.75	2.09
0.4	1.60	2.00	2.46	2.10	1.86	1.80	1.62	1.90
0.5	1.57	1.70	2.10	1.90	1.72	1.70	1.58	1.75
Average	1.62	1.90	2.31	2.02	1.86	1.79	1.65	
LSD for days	0.02							
LSD for doses	0.02							

Table 4. Effect of carbamate pesticides on total copper of soil with variation in concentration and time

Dose in g per kg of soil	Total copper in ppm at various days							Average
	1	15	30	45	60	75	90	
				Oxamyl				
0.0	52.14	53.32	54.38	53.82	53.32	52.62	52.04	53.10
0.1	57.88	55.62	56.98	56.10	55.62	55.24	52.04	54.78
0.2	52.02	58.22	59.38	58.80	58.10	57.72	52.04	56.61
0.25	52.22	60.20	61.82	60.64	60.06	58.38	52.46	58.00
0.3	51.76	57.34	58.66	57.74	57.22	56.82	52.46	56.00
0.4	51.88	55.24	56.60	55.52	54.92	54.62	52.04	54.40
0.5	52.14	53.60	54.98	54.12	53.46	53.20	51.14	53.30
Average	52.00	56.21	57.54	56.67	56.10	55.12	52.09	
LSD for days	0.24							
LSD for doses	0.26							
				S-Ethyl-N-(methyl(carbamoyl oxy) thioacetimidate				
0.0	52.14	53.34	54.69	53.92	53.32	52.12	52.16	53.21
0.1	52.26	57.52	58.74	57.90	57.02	56.24	53.62	56.19
0.2	52.46	61.32	65.34	63.24	62.00	61.24	53.62	59.89
0.25	52.14	60.08	61.76	60.58	60.14	58.54	53.86	58.11
0.3	51.88	58.26	59.72	58.58	58.11	57.72	53.86	56.88
0.4	52.14	56.00	57.12	56.44	55.72	55.32	53.86	55.23
0.5	52.26	55.16	56.68	55.82	55.00	54.62	53.24	54.70
Average	52.18	57.39	59.14	58.08	57.33	55.66	13.47	
LSD for days	0.25							
LSD for doses	0.34							
				N-Phenyl-(ethyl carbamoyl) propyl carbamate				
0.0	52.14	13.04	54.33	53.60	53.00	52.52	51.76	52.97
0.1	52.26	55.38	57.82	55.20	53.98	53.88	57.76	54.23
0.2	52.42	58.16	61.64	60.02	59.52	58.72	53.45	57.71
0.25	53.14	60.56	63.34	61.82	60.60	60.65	54.35	59.12
0.3	53.14	61.22	65.04	63.00	61.54	61.00	54.35	59.79
0.4	52.42	57.05	60.42	58.48	57.00	56.42	51.76	56.22
0.5	52.14	53.72	56.34	54.24	53.75	53.24	51.76	53.60
Average	52.66	57.00	59.75	58.34	57.05	56.55	52.61	
LSD for days	0.34							
LSD for doses	0.43							

Table 5. Effect of carbamate pesticides on total cobalt of soil variation in concentration and time

Dose in g per kg of soil	Total cobalt in ppm at various days							
	1	15	30	45	60	75	90	Average
				Oxamyl				
0.0	19.14	20.52	21.15	20.48	20.00	19.80	19.65	20.11
0.1	19.24	21.04	21.86	21.22	20.62	20.62	20.30	20.70
0.2	19.16	21.26	22.86	21.96	21.64	21.24	20.92	21.29
0.25	19.10	22.59	23.94	23.04	21.82	21.62	21.52	21.95
0.3	19.20	21.60	23.22	22.40	21.50	21.10	20.86	21.41
0.4	19.13	21.22	22.18	21.60	20.72	20.42	20.36	20.80
0.5	19.26	20.80	21.52	20.86	20.04	20.04	19.58	20.36
Average	19.17	21.29	22.39	21.35	20.91	20.69	20.51	
LSD for days	0.28							
LSD for doses	0.32							
				S-Ethyl-N-(methyl(carbamoyl oxy) thioacetimidate				
0.0	19.16	21.22	22.46	21.63	20.89	20.45	20.45	20.90
0.1	19.45	22.54	23.66	22.72	22.18	21.82	20.45	21.84
0.2	19.57	22.88	24.52	23.72	23.42	23.02	20.45	22.80
0.25	19.45	22.32	23.94	23.09	23.06	21.68	20.45	22.00
0.3	19.16	21.20	22.82	21.96	21.24	20.88	20.45	21.09
0.4	19.16	21.02	22.20	21.62	20.95	20.45	20.24	20.81
0.5	19.16	20.90	22.00	21.52	20.64	20.45	20.24	20.70
Average	19.30	21.72	23.09	22.32	21.77	21.25	20.39	
LSD for days	0.38							
LSD for doses	0.31							
				N-Phenyl-(ethyl carbamoyl) propyl carbamate				
0.0	19.16	21.64	22.96	22.12	21.35	20.90	20.90	21.12
0.1	19.28	22.85	24.12	23.02	22.36	22.28	20.90	22.12
0.2	19.36	24.15	26.26	24.56	24.16	23.62	21.48	23.37
0.25	19.46	24.96	27.16	25.49	25.40	24.18	21.48	24.02
0.3	19.49	25.12	27.22	25.51	25.14	24.02	21.56	24.03
0.4	19.36	23.28	25.02	23.82	23.04	22.86	20.90	22.61
0.5	19.28	22.50	23.64	22.66	22.08	21.82	20.90	22.84
Average	19.34	23.50	25.19	23.88	23.36	22.81	21.16	
LSD for days	0.33							
LSD for doses	0.42							

Table 6. Correlation coefficients in between availabe copper, total copper, water soluble B, total cobalt, pH, EC and redox potential (Eh) for three carbamate pesticides

	Total cobalt in ppm at various days					
From	Total Cu	Water soluble B	Total Co	pH	EC	Eh
			Oxamyl			
Available Cu	0.944	0.888	0.932	-0.866	0.914	0.944
Total cu	-	0.979	0.979	-0.838	0.924	0.922
Water soluble B	-	-	0.985	-0.856	0.914	0.936
Total Co	-	-	-	-0.850	0.910	0.912
pH	-	-	-	-	-0.912	-0.806
EC	-	-	-	-	-	0.936
			S-Ethyl-N-(methyl carbamoyl oxy) thioacetimidate			
Available Cu	0.988	0.927	0.946	-0.872	0.889	0.934
Total cu	-	0.944	0.923	-0.846	0.912	0.920
Water soluble B	-	-	0.886	-0.840	0.924	0.902
Total Co	-	-	-	-0.852	0.914	0.916
pH	-	-	-	-	-0.910	-0.824
EC	-	-	-	-	-	0.914
			N-Phenyl-(ethyl carbamoyl) propyl carbamate			
Available Cu	0.977	0.988	0.970	-0.912	0.887	0.916
Total cu	-	0.990	0.992	-0.886	0.910	0.924
Water soluble B	-	-	0.986	-0.884	0.896	0.910
Total Co	-	-	-	-0.906	0.910	0.924
pH	-	-	-	-	-0.876	-0.812
EC	-	-	-	-	-	0.906

Table 2 indicates that the concentration of available copper was in the dose order $t_3 > t_2 > t_4 > t_1 > t_5 > t_6 > t_0$ for pesticide I, $t_2 > t_3 > t_4 > t_1 > t_5 > t_0 > t_6$ for pesticide II and $t_4 > t_3 > t_5 > t_2 > t_1 > t_6 > t_0$ for pesticide III after 30 days of application. Almost similar effect occurs with total copper (Table 4). An increase in available copper may be due to solubilisation with decrease in pH, caused by soil fungi as Aspergillus niger and bacteria such as Thiobacillus (Torma, *and Legault* 1973). The negative influence on available copper was due to reduction in biological activity by high doses of pesticides and due to the adsorption of available copper by soil minerals. On the other hand, increase in total copper in the soil was derived from the toxic effect of pesticides on certain microorganisms. As these organi were killed by pesticide, their protoplasmic constituent such as cytochrome oxidase (Grewal *et al.* 1969 ; Agnihotri, 1978) came into soil which cause an increase in copper. Decrease in copper with passage of time is due to the decline in the effect of pesticides and re-establishment of pesticide sensitive micro-organisms (Alexander, 1973). These observations are supported by microbial population (Table 1).

The influence of different doses of three carbamate pesticides (Table 5) on total cobalt is almost same as in copper. The increase in concentration of total cobalt was derived form the protoplasmic constituent and vitamin B_{12} of the dead bacteria (Alexander, 1973) as a result of pesticide treatment which followed by re-establishment of the micro-oganisms after a certain period due to the gradual decay of chemical leading to a decrease in cobalt status of the soil caused by its absorption by the bacteria (Table 1). The above inferences were supported by change in pH, Eh and EC.

An examination of the correlation coefficients (Table 6) reveals that there is a significant positive correlation between water soluble boron, available copper, total cobalt, EC and Eh and negatively correlated to pH. Pointing to an almost similar mechanism for their variation in the soil

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EFFECT OF SEASON ON THE VEGETATIVE AND REPRODUCTIVE ATTRIBUTES OF GUAVA CV. RED FLESHED

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ABSTRACT

A study was conducted to assess the impact of different seasons on the growth, flowering and fruiting attributes of guava cv. Red fleshed. In different cropping seasons, maximum extension growth was recorded in spring season followed by rainy and winter season. Maximum number of flowers emerged and dropped in summer season flowering followed by rainy and autumn flowering, while the maximum percentage of fruits set was observed in autumn season flowering. Highest yield per plant was obtained in rainy season followed by winter and spring season, while maximum T.S.S., total sugar, acidity and vitamin C. content were found in winter season cropping followed by spring and rainy season.

Key words : Vegetative growth, flowering, fruiting, rainy season, winter season and spring season.

Guava (*Psidium guajawa* L.) is one of the most exquisite and valuable fruits of the tropics. However, despite of overwhelming consumer acceptance, there is a dearth of information on different cropping patterns, which is absolutely essential for proper management of cultural practices and marketing. On the most critical botanical characteristics of guava is that flowers are always borne on newly emerging vegetative shoots irrespective of the time of year (Singh *et al.* 2000). Consequently, flowering and fruits set can be very erratic depending on the environmental conditions (Singh *et al.* 2000). In northern India, three distinct flowering seasons i.e. summer, rainy and autumn with corresponding harvesting periods in rainy winter and spring have been observed. The ripening and quality of guava fruits is greatly influenced by the prevailing atmospheric temperature and humidity conditions. The development of sweetness, colour and aroma is dependent on low temperature and dry atmosphere. Therefore, to collect the detailed information on the effect of season on various characters of guava were studied under Sabour conditions.

MATERIALS AND METHODS

Eighteen years old plant of guava cv. Red fleshed, spaced 6 x 6 m^2. apart in Horticultural Garden of Department of Horticulture, Sabour during 1997-98 and 1998-99 was selected for the study. Single plant considering as unit was replicated six times in completely randomized design with three treatments (rainy, winter and spring seasons). The observations consisted of vegetative growth, flowering fruit-yield and physico chemical quality of fruits.

In all the three seasons, vegetative growth was studied by recording the observations on extension growth of shoots. Ten shoots in each unit were randomly selected for recording data. For physico-chemical characters, the fruits were collected from all the sides of the plants at the right stage of ripening and the observations were recorded based on ten randomly selected fruits. T.S.S. and titratable acidity were determined by standard methods. Fehling solution method advocated by Lane and Eynon (1943) was followed for estimating sugars. Ascorbic acid content was determined by titrating freshly extracted juice against 2,6-dichlorophenol indophenal dye (AOAC 1977).

RESULTS AND DISCUSSION

Maximum extension of terminal shoots was recorded in spring season i.e 13.11 and 14.10cm. year 1997 and 1998, respectively followed by rainy and winter season. The growth pattern of lateral shoots was also recorded the same as in terminal shoots. Terminal and lateral shoots grew very fast initially for first four months, thereafter, it slowed down as shoot matured. Growth of terminal shoots was faster than the lateral shoots. Maximum growth during spring season was due to active growth phase, minimum load on the tree and congenial atmospheric conditions. While minimum growth in winter season wad due to low temperature. The same growth pattern of shoots was recorded by Singh *et al* (2000) in guava.

Table 1 reveals that there are mainly three flowering seasons i.e. summer, rainy and autumn. However, flowering was heavy in summer, medium in rainy and light in autumn. The peak period of flowering was recorded in the last weak of April in summer last fortnight of July in rainy and November in autumn crop. The seasonal influence was very much pronounced on the number of flowers borne. Maximum number of flowers per plant was borne in summer flowering, medium in rainy and light in autumn flowering and it showed significant differences. However, highest percentage of fruit set was recorded in autumn flowering followed by rainy and summer season flowering. Differences in the percentage fruit set among all the seasons were significant during the both the years.

The time, duration, rate of flowering, in guava is governed by the season and the cropping pattern (Dwivedi *et al.* 1990). Both these factors are likely to affect the food reserves of the plant. Since flowering and vegetative growth during winter is almost negligible, the plants accumulate sufficient food reserves, which is responsible for the initiation of new growth in the following spring. Due to heavy flowering in March-April and fruiting in the rainy season the food reserves were exhausted, therefore the rainy season flowering (July-August) for winter season cropping was less as compared with flowering in the March-April (Dwivedi *et al.* 1990). The percentage of fruit set was higher in the spring season crop followed by winter and rainy season. The hot summer appear to be the main

Rathore and Singh (1974), cause of the poor fruit set in rainy season crop.This was in accordance with the findings of Dwivedi *et al.*(1990) and Singh *et al,* (2000) in guava.

Data with respect to yield per tree are presented in Table 1. The rainy season crop has given maximum yield in both the years followed by winter and spring season. The same trend in yield per plant was also recorded in individual years. This is because of full utilization of the yield potential by the plants. Maximum yield in rainy season may be due to higher number of flowers obtained in summer flowering. While due to exhaustion of the food reserves by the rainy season crop, less number of flowers and fruits were produced on the three during other cropping seasons. Similar results were obtained by Dwivedi *et al.* 1990 in guava cv. Sardar. Size of the fruits was recorded in terms of length, width and weight of the fruits. It is obvious form the Table 2 that maximum fruits length, width and weight of the fruits were recorded in winter season followed by spring and rainy seasons in all the two years of observation and it showed significant variation in almost all the cases. Because of restricted fruits to leaf ratio and limited exposure of light due to cloudy weather, probably less photosynthates were available for fruit growth in rainy season, hence medium to smaller size fruits obtained. However, during winter season, fruits received more organic metabolites and thus gained weight because of higher leaf fruits ratio and better exposure to light. Similar observations were recorded by Dwivedi *et al.,* 1990 in guava cv. Sardar.

It is clear from Table 3 that maximum T.S.S., total sugar, acidity and vitamin C contents were found higher in winter season followed by spring and rainy seasons in both the years of experimentation. Winter season fruits had significantly higher values of various quality attributes as compared to spring and rainy season crops, respectively. The percentage of various constituents in the rainy season were low due to cloudy weather and presence of relatively more moisture which must have moved into the fruits from the wet soil and diluted the organic metabolites, particularly sugars (Dwivedi *et al.*, 1990). The inferior quality of the spring season fruits of guava might be attributed due to the initiation of new growth coupled with leaf fall and also

Table 1. Seasonal variation in growth and reproductive attributes in guava cv. Red Fleshed

Cropping	Year	Extension growth (cm) Terminal shoot	Extension growth (cm) Lateral shoot	Average No. of flowers/tree	Per cent fruits set	Yield /tree (kg)
Rainy	1997-1998	11.10	11.45	525.00	53.00	74.11
	1998-1999	13.90	9.78	450.11	50.91	78.91
Winter	1997-1998	3.19	5.43	348.00	57.11	22.11
	1998-1999	3.98	5.11	338.11	59.11	18.11
Spring	1997-1998	13.19	13.11	140.00	69.19	7.12
	1998-1999	14.78	14.10	136.00	74.12	6.00
C.D. at 5%	1997-1998	1.13	2.10	16.11	4.90	5.13
	1998-1999	1.73	2.11	23.93	4.13	6.11

Table 2. Seasonal variation in fruit size in guava cv. Red fleshed

Cropping	Year	Length (cm)	Width (cm)	Weight (g/fruit)
Rainy	1997-1998	4.30	4.41	86.00
	1998-1999	4.16	4.47	80.00
Winter	1997-1998	5.40	5.67	16.00
	1998-1999	5.60	5.47	172.00
Spring	1997-1998	4.41	5.29	110.00
	1998-1999	4.26	5.23	116.00
C.D. at 5%	1997-1998	0.53	0.53	7.63
	1998-1999	0.67	0.61	8.11

Table 3. Seasonal variation in fruit quality attributes in guava cv. Red Fleshed

Cropping	Year	TSS(%)	Acidity(%)	Total sugar (%)	Vitamin C (mg/100g)
Rainy	1997-1998	9.13	0.31	6.69	125.00
	1998-1999	9.34	0.32	6.36	169.67
Winter	1997-1998	11.34	0.42	9.12	229.00
	1998-1999	10.90	0.41	8.98	270.00
Spring	1997-1998	11.20	0.37	6.93	198.00
	1998-1999	11.15	0.38	6.83	190.00
C.D. at 5%	1997-1998	0.41	0.05	0.61	1530
	1998-1999	0.48	0.04	0.51	12.98

prevalence of higher atmospheric temperature at the time of fruit growth and development in phase III of their growth.

Best quality fruits were obtained in the winter season followed by spring and rainy season during both the years of study. These results are in conformity with the findings of Dwivedi *et al.*, (1990). The low temperature during the ripening period of winter season crop in guava retard the excessive loss of respiratory substrates and also increased translocation to the better quality fruits during winter, is the coincidence of low temperature with phase III of fruit growth. Maximum vitamin C, Content was found in winter seasons followed by spring and rainy season during both the years of experimentation. Similar findings wee recorded by Dwivedi *et al.*, 1990 in guava cv. Sardar and Srivastava.

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CONSERVATION AND EVALUATION OF RICE BIODIVERSITY UNDER TEMPERATE CONDITIONS OF KASHMIR

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ABSTRACT

Divergence analysis based on 50 local rice cultivars/land races collected from temperate higher lower hills of Kashmir led to the formation of 5 clusters with cluster 1 having maximum number of genotypes. Maximum intra cluster distance was revealed by cluster 5 (28.56), whereas, maximum inter cluster was between cluster 4 and cluster 5. 1000-grain weight followed by grain yield per plat and panicle length contributed maximum to the divergence of local rice cultivars. Tremendous potential exists for introgression the allelic resources present in these adopted local cultivars into exotic high yielding recover high yielding quality recombinants.

Key words *:* Genetic divergence, conservation, rice

Cultivation of high yielding rice varieties has brought the danger of genetic vulnerability as genetic uniformity of improved high yielding rice has replaced the cultivation of a large number of location specific rice cultivars/land races. In Kashmir valley, the expansion of area under a few genetically uniform and high yielding rice varieties has led to risk of genetic erosion of land races/adopted rice cultivars growing over centuries in agro-and/or location specific regions. The local germplasm resources have been pushed into smaller areas and likely to face extinction. Judging from the importance of bio-diversity for these cultivars/land races, it is important to document them for use in the future breeding programmes involving exotic x local hybridization programme. Keeping in view the present need for planned management of these resources through scientific conservation and sustainable utilization, the present investigation was carried out to promote present day rice improvement efforts.

MATERIALS AND METHODS

The material for the present study was generated through an exploratory survey of temperate higher and lower hills of Kashmir valley. Exploratory areas of temperate higher hills included Wandiwalgam, Larnoo, Pahalgam. Qazigund, Tangmarg, Kanidajan, Trajkhal, Sonamarg and Pinjura, whereas, Lower hills of Kashmir included Look Bhawan, Hakura, Bujwain, Arwah, Margund, Wagura, Chandoosa, Langeth and Chaknutnusa. Population sample of cultivated farms of rice were collected following random sampling technique. The collection sites mainly included farmers fields. The mature seed from fifty to hundred plants from each population were sampled and in all fifty local rice cultivars/ land races were collected, and were evaluated along with two high yielding varieties of rice viz., Jehllum and Chenab (checks). The experimental plot consisted of 3 rows each of 5 cm length. The rows were spaced 20 cm apart. At each hill 2-3 seedlings were planted maintaining hill to hill spacing of 15 cm. Five competitive plants were selected at random from each experimental plot in a replication. Mean values for yield components and quality traits & medium values for day to maturity were worked out and subjected to statistical analysis standard procedures.

RESULTS AND DISCUSSION

Mahalanobis D^2 statistics revealed that values of V statistics (measuring Wilk's criteria) were high and significant indicating presence of substantial genetic diversity in the material. Classification of cultivars led to the formation of 5 clusters (Table 1). Cluster 1 contained maximum number of genotypes (41), followed by cluster 2(6), whereas, cluster 3 contained 1 cultivar. The remaining 2 clusters contained two cultivars each. Both the high yielding varieties used as checks got clubbed in cluster 5. Considering the grouping of cultivars into different clusters, it was observed that cultivars presently growing in different pockets had no tendency to group together in a cluster, revealing that there was no parallelism is the geographical genetic diversity. Similar results were reported by several rice workers Sinha *et al.,* 1991).

Mean intra and inter cluster distances (Table 2) revealed that intra cluster distance was maximum in cluster 5 ()28.56), followed by cluster 4 (16.78), cluster 1 (13.64) & cluster 2(12.90). The inter cluster distance was maximum between cluster 4 and cluster 5 (159.44), however, cluster 5 had high inter cluster D^2 values with all other clusters. Thus it is clear that tremendous potential exists for intercrossing the allelic resources present in these adopted local cultivars into exotic high yielding genotypes through a systematic breeding and selection approach so as to recover high yielding recombinants possessing also good quality characteristics.

Cluster means (Table 3) for different agro-morphological traits revealed that substantial genetic variability existed for all the traits, however, the genetic variation was maximum when the clusters representing local cultivars were compared with cluster representing standard checks. The highest cluster means for different traits viz., panicle length (27.24), grains per panicle (158.87), grain yield per plant (24.29), 1000 grain weight (28.65), and kernel L:B ratio (2.35) was exhibited by cluster 5 accommodating standard checks. In rest of the clusters accommodating local rice cultivars/land races the highest cluster mean for different traits were : panicle length (22.58) cluster I, grains per panicle (137) cluster 3, grain yield per plant (16.47) cluster 3, 1000 grain weight (24.36) cluster 2, and kernel length : breadth ratio (2.0) cluster 3. The results clearly indicate that among local rice cultivars/land race *Reshim* exhibited highest mean performance for gans per panicle, grain yield per plant and kernel length: breadth ratio. Cluster means of different clusters identify the characters to chosen for hybridization. Sardana *et al.* (1997) observed that cluster means and coefficient of variation are on interacting picture of diversity.

In the present study the traits

Table .1 Classification of the local rice cultivars and checks into different clusters

Cluster	Cultivars included in the cluster	Number of cultivars in the clusters
Cluster 1	*Mush Kandi-I, Wate Zag I, Tumla Hall, Noor Meri, Bala anzul, Gulla Bara, Poot Brear, Kamad, Meer Zag, Umber Zul, Prenie Zaged, Begum, zagri Purple, Aziz Beoul, Loul anzul, Rehman Bhati I, Niver Zag, Kala Brear I, Zagir, Rama Hall, Nun Boul, Gull Zag, Mugal, Mushki Budji, Safed Budji, Niver, Guru Kanue, Prunch Wall, Zag Baber, Mazzete I, Mehwan (G), Barat, Black rice Baber, Larbeoul, Tumla Zag, Safed Brez, Tilla Zag, Shahie, Tral Zagir Karwara,*	41
Cluster 2	*Qadir Baing, Safed Brez, Bala Kouni, Brez, Khuch, shalla Kew (1),*	6
Cluster 3	Reshim	1
Cluster 4	*Batu Baber, Prenie Baber*	
Cluster 5	*Jehllum, Chenab*	

Table 2. Mean and inter cluster distance (D^2) among the local rice cultivars and standard checks

Cluster No.	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Cluster 1	13.64	34.32	29.37	73.57	99.61
Cluster 2		12.90	41.19	103.40	81.93
Cluster 3			0.00	79.32	82.11
Cluster 4				16.78	159.44
Cluster 5					28.56

Table 3. Cluster means for different traits in local rice cultivars adopted to temperate conditions of Kashmir

Cluster. No	No. of cultivars in a cluster	Days to maturity	Panicle length (cm)	Grains Panicle^{-1}	Grain yield plant^{-1} (g)	1000 grain weight (g)	Kernal L:B ratio
1	41	125.11	22.58	88.63	11.59	21.88	1.91
2	6	125.16	22.00	87.66	11.25	24.36	1.83
3	1	129.00	20.25	137.00	16.47	22.47	2.00
4	2	127.50	22.10	104.85	11.95	16.14	1.68
5	2	137.000	27.24	158.87	24.29	28.65	2.35

Table 4. Contribution of different maturity, yield component and quality characters towards total divergence among local rice cultivars adopted to temperature climatic conditions of Kashmir

Trait	Number of times appearing first in the rank	Precent contribution towards total divergence among the material studied
Days to maturity	14	1.06
Panicle length	150	11.31
Grains Panicle^{-1}	95	7.16
Grain yield plant^{-1} (g)	246	18.55
1000 grain weight (g)	698	52.64
Kernal L:B ratio (mm)	123	928
	1326	**100.00**

contributing maximum to the divergence of the local rice cultivars (Table 4) adopted to Kashmir climatic conditions were observed to be 1000 grain weight (52.64%), followed by grain yield per plant (18.55%), panicle length (11.31%), kernel L:B ratio (9.28%) and grains per panicle (7.16%). Days to maturity made a negligible contribution towards total divergence. De *et al.* (1998) proposed that traits contributing maximum towards the D^2 value need to be given great emphasis for deciding on the clusters to be chosen for the purpose of further selection and choice of parents for hybridization. Greater contribution of grain yield per plant towards total divergence has been reported by several workers (Vivkakanandan and Subramanian, 1993; Singh *et al.*, 1996; Ahmad and Borah, 1999).

In the present study genetic divergence was observed to exist between several clusters grouping local cultivar. However, this genetic divergence was more when the cluster grouping local cultivars were compared to high yielding commercial varieties having exotic background. The local cultivars could thus be, improved upon for higher yield potential and quality parameters by making crosses between local x exotic gene pool.

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STUDIES ON FLOWER AND POLLEN CHARACTERISTICS IN SOME NEW INTRODUCTIONS OF PLUM

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ABSTRACT

The cultivars of plum viz. Florida 1-2, Sweet Early, Red Beaut, Frontier, Kanto-5, Tarrol, Santa Rosa, Au-Rosa, Au-Amber and Red Ace, have been studied for their floral and pollen characteristics. The variations were observed with respect to size of flower, petals, sepals, length of stamens and pistil and time of full boom. Pollen fertility under staining and germination tests was 77.08 to 93.05 per cent and 14.46 to 58.57 per cent, respectively. The maximum germination of pollen grains was observed in 15 per cent sucrose+10 ppm boric acid.

Key words : Plum, floral and pollen characters, pollen germination.

Plum is widely cultivated stone fruit of the temperate region throughout the world. It ranks next to peach in importance so far as its economic value is concerned. In India plum tree thrives well in the low hills and submontaineous tracts where the high requiring apple and cherry can not be grown profitably. In Himachal Pradesh plum cultivation is dominated by a single cultivar Santa-Rosa. This monoculture results in the glut market and reduces the returns to the farmers. To overcome this problem the new varieties are being introduced and evaluated for various characteristics have got a great bearing on the breeding programme as well as on the fruitfulness and ultimate yield of the fruit crop. Therefore, keeping in view the importance of floral and pollen characteristics in the successful cultivation of a cultivar the present studies have been carried out.

MATERIALS AND METHODS

The investigations were carried out in the plum collection block of the Department of Fruit Breeding and Genetic Resources, which is located at 1225 m above mean sea level. Three trees of each cultivar viz. Au-Amber, Au-rosa, Florida 1-2, Frotier, Kanto-5, Red-ACe, Red Beaut, Santa Rosa, Sweet Early and Tarrol were studied with respect to their flower and pollen characteristics, fifteen freshly opened flowers in three replications were taken for studying floral biology. The pollen length and breadth were measured with ocular micrometer after calibration with stage micrometer. Pollen fertility was assessed through staining in one per cent acetoarmine solution and pollen germination in sucrose-boric acid by using banging drop method. Different concentrations of sucrose + boric acid solution were used:

a) 5% sucrose + 10 ppm Boric acid
b) 10% sucrose + 10 ppm Boric acid
c) 15% sucrose + 10 ppm Boric acid
d) 20% Sucrose+10 ppm Boric acid
e) 10% Sucrose
f) 15% Sucrose

RESULTS AND DISCUSSION

The flowers were borne on buds on one year old shoots and spurs. The data on flower morphology are presented in Table 1.

The flower spread varied from 2.16 and to 2.71 cm. The petalsize (length x breadth) was maximum (1.13 x 1.06 cm) in Florida 1-2 minimum (0.88x0.90 cm) in Au-Rosa. The special size maximum (.46x.42 cm) in Florida 1-2 and minimum (0.25 x 0.23 cm) in Kanto-5. The average number of stamen per flower ranged between 25.38 in Florida 1-2 and 35-98 in Kanto-5. The length of stamen was highest (0.92 cm) in Tarrol and lowest (0.75) in Au-Rosa Santa Rosa and Santa Rosa. The pistil length from 0.85 cm in Au-Rosa to 1.07 cm in Tarrol.

The data in Table 2 indicate that the full bloom was earliest (18 the Feb.) in Florida 1-2 followed by Sweet Early, Red Beaut, Frontier, Santa Rosa, Au-Amber, Red Ace and Tarrol, Au-Rosa and 'Kanto-5 was' the latest (21 March) to reach the full bloom.

The significant variations in floral parts have also been reported Suranyi (1994) and

Table 1. Flower morphology of some cultivars of plum

Cultivars	Flowers spread (cm)	Petal size (cm)		Sepal size (cm)		No. of stamens per flower	Lengthof stamen (cm)	Length of pistil (cm)
		Length	Breadth	Length	Breadth			
Au-Amber	2.43	0.99	0.95	0.40	0.38	30.45	0.78	0.97
AU-Rosa	2.27	0.88	0.90	0.35	0.36	29.59	0.75	0.85
Florida 1-2	2.71	1.13	1.06	0.46	0.42	25.38	0.88	0.95
Frontier	2.38	0.97	1.04	0.43	0.44	28.08	0.77	0.89
Kanto-5	2.39	0.98	0.96	0.25	0.23	35.98	0.82	0.94
Red Ace	2.16	0.89	0.91	0.29	0.32	30.13	0.81	1.01
Red Beaut	2.56	1.03	0.99	0.35	0.31	27.33	0.81	0.87
Santa Rosa	2.35	0.96	0.94	0.31	0.29	29.42	0.75	0.90
Sweet Early	2.32	0.93	0.90	0.32	0.30	28.13	0.79	0.92
Tarrol	2.19	0.91	0.89	0.37	0.35	26.54	0.92	1.07
S.E.	0.01	0.02	0.01	0.01	0.01	1.23	0.01	0.01
C.D.$_{0.05}$	0.03	0.04	0.03	0.02	0.03	2.58	0.02	0.03

Mohapatra (1994) in different plum cultivars.

The length and breadth of pollen grains varied from 35.56 um to 45.47 um and 19.89 um to 25.58 um, respectively. The pollen fertility through staining test showed that the pollen grains in Red Beaur are sterile, whereas in other cultivars it ranged between 77.78 per cent and 93-05 per cent (Table 3). Similar results were also obtained by Bajwa *et al.* (1991) and Lal (1993).

The pollen fertility as assessed by germination tests also showed that the pollen grains of Red Beaut are sterile. Childers *et al.* (1995) has also reported the sterile nature of the Red Beaut pollen grains. In

Table 2. Time of flowering in some plum cultivars

Cultivars	Date of opening of first flower	Date of full bloom	Date of opening of last flower	Duration of flowering (number of days)
Au-Amber	07.03.199	16.03.1999	24.03.1999	18
AU-Rosa	11.03.1999	19.03.1999	24.03.1999	14
Florida 1-2	09.02.1999	18.02.1999	23.02.1999	15
Frontier	26.02.1999	05.03.1999	10.03.1999	13
Kanto-5	12.03.1999	21.03.1999	25.03.1999	14
Red Ace	08.03.1999	17.03.1999	23.03.1999	16
Red Beaut	22.02.1999	03.03.1999	06.03.1999	13
Santa Rosa	01.03.1999	10.03.1999	15.03.1999	15
Sweet Early	19.02.1999	02.03.1999	06.03.1999	18
Tarrol	09.03.199	17.03.1999	26.03.1999	18

Table 3. Morphology and fertility of pollen in some plum cultivars

Cultivars	Pollen length (µm)	Pollen breadth (µm)	Pollen fertility (per cent)
Au-Amber	39.79	19.89	82.71 (9.0780
AU-Rosa	41.21	24.16	85.25(9.233)
Florida 1-2	35.56	21.32	86.67(9.309)
Frontier	39.53	25.15	93.05(9.6460)
Kanto-5	38.37	25.58	90.05 (9.489)
Red Ace	45.47	21.32	77.78(8.819)
Red Beaut	39.79	21.32	0.00(0.71)
Santa Rosa	44.79	22.09	89.83 (9.477)
Sweet Early	42.46	25.58	88.24(9.393)
Tarrol	43.65	22.74	88.24(9.393)
S.E.	1.15	0.86	0.10
C.D.$_{0.05}$	2.41	1.82	0.21

Table 4. Pollengermination in different concentrations of sucrose solution

Cultivars	Concentration						
	Sucrose (5%) and boric acid (10 ppm)	Sucrose (10%)	Socrose (10%) and boric acid (10 ppm)	Socrose (15%)	Socrose (10%) and boric acid (10 ppm)	Socrose (20%) and boric acid (10 ppm)	Mean
Au-Amber	14.46	19.46	23.95	32.66	33.97	23.05	24.59
	(22.29)	(26.16)	(29.29)	(34.85)	(35.64)	(28.67)	(29.48)
AU-Rosa	19.67	25.81	29.57	38.00	39.50	30.16	30.54
	(26.31)	(30.52)	(32.93)	(38.03)	(38.94)	(33.30)	(33.34)
Florida 1-2	20.85	30.51	37.98	49.30	54.11	34.02	37.79
	(27.16)	(33.53)	(38.04)	(44.60)	(47.36)	(35.68)	(37.73)
Frontier	15.90	25.28	31.64	40.01	40.25	29.71	30.46
	(23.49)	(30.19)	(34.29)	(39.24)	(39.37)	(33.02)	(33.25)
Kanto-5	21.05	24.18	26.95	38.10	45.58	27.29	30.52
	(27.27)	(29.45)	(31.24)	(38.10)	(42.46)	(31.47)	(33.33)
Red Ace	17.39	22.39	29.32	46.46	54.33	31.04	33.99
	(24.64)	(28.24)	(32.78)	(44.69)	(47.48)	(33.85)	(35.28)
Red Beaut	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Santa Rosa	21.54	27.99	30.20	56.18	58.57	27.90	37.06
	(27.64)	(31.93)	(33.33)	(48.55)	(49.95)	(31.87)	(37.21)
Sweet Early	19.49	32.82	34.05	46.91	47.34	31.88	35.41
	(26.20)	(34.95)	(35.70)	(43.23)	(43.47)	(34.37)	(36.32)
Tarrol	20.98	27.89	28.52	40.89	44.02	24.62	31.15
	(27.24)	(31.85)	(32.26				
Mean	17.13	23.63	27.22	39.15	41.77	25.97	29.14
	(23.22)	(27.68)	(29.98)	(37.10)	(38.62)	(29.20)	(30.97)

Figures in parenthese are arc sine transformed values rest of the cultivars pollen fertility varied from 14 46 per cent to 57.57%. It was maximum in 15% Sucrose+10 ppm boric acid solution. The results on germination test (Table 4) indicate that boron enhances germination which is in accordance with the findings of Visser (1955) and Singh *et al* (1961) in which they found that boron enhance the pollen germination in fruit crops. The pollen grains of Red Beaut cultivar showed no fertility under both staining and germination tests.

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ESTIMATION OF EVAPOTRANSPIRATION OF WHEAT CROP IN A RICE-WHEAT CROPPING SYSTEM BY VITT APPROACH USING SPECTRAL INDICES AND INFRARED THERMOMETRY

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ABSTRACT

At tempts have been made in the past by a umber of workers to use the canopy thermal data for estimation of crop evapotranspiration using number of energy balance models including some physical constants. The study carried out here deals with a integrated approach for estimation of crop enapotranspiration for rice and wheat by the VITT approach using spectral indices and the canopy thermal data. The results revealed that the VITT approach was more suitable for estimation of crop evapotranspiration rate for higher value of spectral indices. The study also emphasized the failure of the model to estimate the evapotranspiration rate of the crop for lower values of the spectral indices.

Key words : Evapotranspiration estimation, wheat, VITT approach, vegetation indices, water availability index.

Remote sensing data by virtue of its high synoptic and temporal capability could be used to monitor a variety of processes governing the crop production system like detection of diseases, stress etc. High level of crop production depend upon complex interactive processes. The factors affecting production includes complex interaction processes involving water, fertility, solar radiation, temperature, crop variety, plant population, weed and disease control measures (Subramanian and Rao, 1985).

Water is however a dominant factor limiting the production. Assuming all other factor to be stable over time, production in a function of water availability including distribution over time and method of application (Dale and Scheerimga, 1977). To compute the crop water requirement on daily or seasonal basis, it is required to calculate the actual evapotranspiration. Actual crop evapotranspiration has been estimated by a number of workers from various method using weather data and some physical constants. With the advent of remote sensing it became easy to the monitor physical processes operating either in regional scale or in global perspective. Canopy temperature and canopy air temperature differences has been used by a number of worker for estimating actual crop evapotranspiration using regression equations (Hieldman *et al,* 1976, Jackson *et al.* 1977). They combined the meteorological data with some physical energy balance equations for estimating crop evapotranspiration. Mostly these methods has a disadvantage that they did not give enough emphasis on the crop conditions or crop growth (Shahi, 1976, Gradner *et al.* 1981). In this perspective the VITT approach was formulated.

MATERIALS AND METHODS

The study was conducted in the research farm area of IARI (Plot no. MB-14D), New Delhi. The latitude and logitude are 28°. 04°N and 77.12°E. The climate is subtropical semi arid. The wheat crop was sown on 4th December, 2000. Randomised Block Design was followed in which there were two irrigation treatments (I_0 and I_1) as main factors and four nutrient treatments under each irrigation treatments as sub factors viz., N_0, N_1, N_2 and N_3 respectively. Each plot size was 5m x 3.5 m and each treatment combination was replicated thrice. The spectral and CATD were monitored along the entire crop growth period and mean value of all the three replication were taken for each observations. Daily instantaneous metrological data was recorded from the automatic weather station (ATS) located close to the study area.

There four nutrient combination under each irrigation treatments were

i) N_0-No nitrogenous fertilizer.
ii) N_1-urea [@ 120 kg N/ha].
iii) N_2-[urea + DCD] & 120 kg N/ha (10% N applied through DCD)
iv) N_3-Urea [@ 60 kg N/ha] + FYM [@ 60 kg N/ha]

The two irrigation were-

i) I_0-5 irrrigations (at CRI, tillering, jointing, anthesis, and milk stage)
ii) I_1-3 irrigations (at CRI, tillering and milk stage)

The four nutrient combinations under each irrigation treatments were same as the rice crop.

The concept proposed here is termed as the VITT (Vegetation indices temperature trapezoid). It is an attempt to combine spectral vegetation indices with composite surface temperature measurements for estimating the water availability index is the ratio of actual evapotranspiration of the crop to the potential evapotranspiration (Moran *et al.* 1994.,Yang *et al.* 1997). Using a spectroradiometer of band width 330 to 1100 mm (model LICOR-1880), the spectral reflectance of the crop was monitored weekly during the active crop growth period. Canopy thermal data viz. Canopy temperature and canopy air temperature differences (CATD) was observed by a hand held infrared thermometer (model-Telatemp. AG - 42) having 4° field of view (FOV) and emmissivity value adjusted to 0.95. Canopy thermal data was taken between 12.00 to 13.00 hours under clear sky conditions. The spectral data were then converted to the spectral indices viz. the radiance ratio and the normalized difference vegetation index (NDVI) respectively. Then the weekly CATD values of all the treatment combinations were plotted in the x axis and the corresponding NDVI values of all the treatments combinations were plotted in the Y axis respectively. Then the stage of the crop where the NDVI values were highest for all treatment combinations was chosen for obtaining the reference point for estimation of the evapotranspiration and calculating water availability index. By a careful observation of the points in the scatter diagram and by some physical; energy balance equations a hypothetical trapezium was drawn connecting the four vertices. Then a straight line was drawn parallel to the base of the trapezium through the reference point. Then from the ratio of the length of a pair line segments the water availability index was calculated. The calculated value was compared to that obtained by the modified Penman method using meteorological data.

Results and Discussion

From Fig. 2 it is clear that at the pre- flowering stage (84 DAS) the NDVI values of all the treatment combinations were highest. So that stage was marked and was used to estimate the crop evapotranspiration rate and to calculated the water availability index. The mean value of the NDVI of all the treatment combinations at those stage was calculated and then the treatment combination whose NDVI values at that stage was closest to that calculated mean NDVI value was chosen as the reference point (C). The corresponding CATD value at that stage was also marked (Fig.1) and the water availability index of the crop at that stage was calculated from the length of two line segments. For wheat crop the water availability index as calculated by the ratio of the length of the line BC to AB (Fig.3.). The ratio of the actual to potential evapotranspiration as calculated by that method was 0.62 at that stage. The ratio of actual to potential evapotranspiration (also called water availability index) as determined

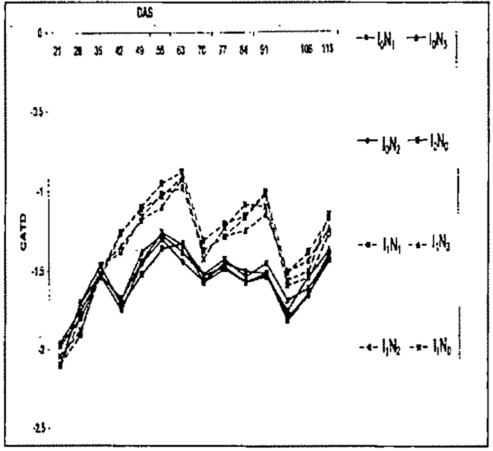

Fig. 1 CATD values of wheat under different treatment combinations

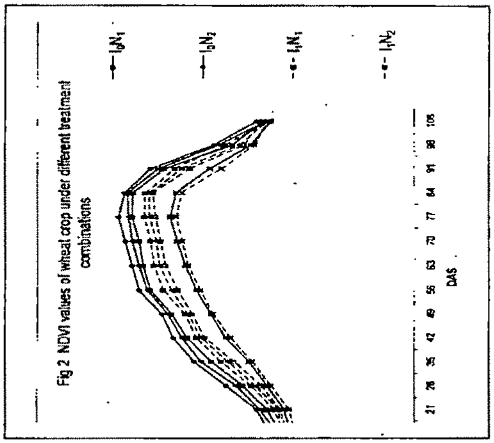

Fig. 2. NDVI values of wheat crop under different treatments combinatins

by modified Penman method for that stage was 0.7 which was much close to the value 0.62 which was determined by the VITT approach.

But in all other stages of the crop VITT approach underestimates the water availability index due to lower vegetation growth and the general tendency of the VITT approach to under estimate the water availability index for lower vegetation cover or vegetation indices (Moran *et al.* 1994).

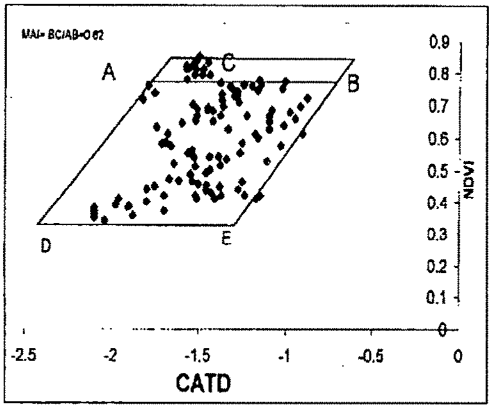

Fig. 3. VITT om WHEAT

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FOLIAR CHLOROPHYLL CONTENTS IN KINNOW MANDARIN AS AFFECTED BY MICRO-NUTRIENTS (Zn, Fe, B) AND ROOTSTOCKS

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ABSTRACT

An experiment was conducted to study the effect of different micronutrients and rootstocks on total chlorophyll content of Kinnow mandarin planted under high density planting. Maximum chlorophyll content 3.010 mg/g fw (1999) 2.984 mf/g fw (2000) was recorded in first flush and 2.758 mg/g few (1999) 2.792 mg/g fw (2000) in second flush by the application of Fe+B. The chlorophyll content was least in control in both the years and in both the seasons. The effect of roots stock was significantly more on Karna Khatta 2.498 mg/g fw (1999) 2.495 mg/g fw (2000) in first and 2.424 mg/g fw (1999) 2.4777 mg/g fw. (2000) in second flush however interaction effect of micronutrient and rootstocks was better on Karna Khatta by the use of Fe+B treatment in both the years.

Key words : Chlorophyll, rootstocks, micronutrients, kinnow, high planting.

The orchard management is one of the major factors in the successful cultivation of fruit crops. The decline of citrus orchard due to chlorosis and deficiency of macronutrients and thereby reduced production of citrus fruits (Huchche *et al.* 1999), specially under high density planting on different rootstocks are major problem in India. Just to prevent hidden hunger and to regulate normal pheno physiological parameters, it is necessary to supplement micronutrients through foliar application. Beneficial effect of micronutrients on citrus plant was also reported by Ram and Bose (2000).

MATERIALS AND METHODS

The 11 year old plant of Kinnow mandarin were planted under high density planting on two different rootstocks viz. Troyer Citrange and Karna Khatta planted at 1.8 x 1.8 m^2 and 2.4 x 2.4 m^2., respectively have been selected for study. The Zn as 0.5% $ZnSO_4$, Fe as 0.4% $FeSO_4$ and B. as 0.2% boric acid were applied on foliage by taking their various combinations singally or doubel and triple. All these treatment combinations of micronutrients were applied at 3 different stage viz., first week of February, first week of June and first week of September in 1999 and 2000. In the both years first (February-March) and second (July-August) flush were analysed by DMSO method to estimate the chlorophyll content.

RESULTS AND DISCUSSION

Total chlorophyll content (mg/g fw)

First flush

The data regarding total chlorophyll content are presented in Table 1. The effect of micronutrients and rootstocks are significant in this connection. The effect of micronutrients irrespective of rootstocks was found significant. The highest mean value (3.010 and 2.984 mg/g fw) was recorded by the application Fe+B followed by Fe (2.96 and 2.820 mg/g. fw). It was significantly lower under control (1.972 and 1.950 mg/g fw.) in 1999 and 2000, respectively.

Besides micronutrients, rootstocks independently influenced chlorophyll content as ti was significantly more (2.498 and 2.495 mg/g fw) on Karna Khatta as compared to the Troyer citrange rootstock.

The interaction of micronutrient, rootstocks were found significant. The highest mean value was recorded under Fe+B (3.017 and 3.027 mg/g fw.) while it was minimum under control on Troyer citrange (1.893 and 1.860 mg/g fw) in 1999 and 2000, respectively.

Second flush

The data of total chlorophyll content of second flush is presented in Table 2. It is revealed from data that irrespective of rootstocks, micronutrients has significant effect on chlorophyll production. The Fe+B treatment was significantly superior (2. 758 and 2.792 mg/g fw) over other treatment followed by Fe (2.697 and 82.711 mg/g. fw.) and it was minimum under control (1.84 and 1.81 mg/g fw) which was significantly lowest in 1999 and 2000, respectively.

Irrespective of micronutrients significant effect of rootstock was observed on total chlorophyll production. It was maximum in Karna Khatta rootstock (2.424 and 2.477 mg) as compared to Troyer citrange rootstock. The interaction effect of micronutrients and rootstocks was significantly maximum (2.973 and 3.027 mg/g fw) on Karna Khatta by spray of Fe+B followed by Fe spray on same rootstock however, it was minimum under control (1.727 and 1.690 mg/g fw) on Troyer citrange rootstock.

The higher chlorophyll synthesis under Fe+B treatment combination followed by Fe alone treatment may be due to key role of Fe in chlorophyll synthesis (Miller *et al.* 1982) and thereby increase in photosynthesis. The better response of Karna Khatta for chlorophyll synthesis over Troyer citrange rootstock may be due to its vigorous root and shoot system as compared to the Troyer citrange. The lower metabolic activity of second flush may be the reason behind content of chlorophyll in this flush . However, the increased chlorophyll content in next year may sbe due to improved health of plants as compare to the first year of experiment. The effect of micronutrients on chlorophyll content was also observed by Devi *et al.*, 1997 in sweet orange and rootstocks and macronutrients by Shukla *et al.* (1999) in Kinnow mandarin.

Table 1. Effect of micronutrients on total chlorophyll (mg/g fw) of 1st flush of Kinnow mandarin on different rootstocks

Treatment	1999			2000		Mean
	Troyer citrange	Karna Khatta	Mean	Troyer citrange	Karna Khatta	
Control	1.893	2.050	1.972	1.860	2.040	1.950
Zn	2.270	2.333	2.302	2.290	2.370	2.330
Fe	2.930	2.983	2.960	2.787	2.850	2.829
B	2.243	2.297	2.270	2.273	2.327	2.300
ZnB	2.753	2.810	2.782	2.683	2.850	2.767
FeB	2.230	2.270	2.250	2.253	2.300	2.276
Mean	2.424	2.489		2.3999	2.495	
C.D. at (P=0.05)						
M		0.026		0.027		
RS		0.052		0.053		
M X RS		0.074		0.075		

Where, M = Micronutrients; RS = Rootstocks

Table 2. Effect of micronutrients on total chlorophyll content (mg/g fw) of IInd on Kinnow mandarin on different rootstocks

Treatment	1999			2000		
	Troyer citrange	Karna Khatta	Mean	Troyer citrange	Karna Khatta	Mean
Control	1.727	1.950	1.840	1.690	1.927	1.810
Zn	2.057	2.273	2.170	2.103	2.323	2.213
Fe	2.467	2.920	2.697	2.443	2.980	2.711
B	2.070	2.257	2.160	2.077	2.293	2.185
ZnFe	1.980	2.087	2.030	2.010	2.227	2.118
ZnB	2.427	2.693	2.560	2.427	2.763	2.595
FeB	2.543	2.973	2.758	2.557	3.027	2.792
Mean	2.164	2.424		2.171	2.477	
C.D. at (P=0.05)						
M		0.028		0.039		
RS		0.056		0.079		
M X RS		0.078		0.111		

Where, M = Micronutrients; RS = Rootstocks

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STUDIES ON COMPARATIVE BIOLOGY OF THE FRUIT FLY, *DACUS CUCURBITAE* COQUILLETT ON RIDGE GOURD AND BITTER GOURD UNDER SEMI-ARID CONDITIONS

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ABSTRACT

The comparative biology of the fruit fly, *Dacus cucurbitae* Coquillett on ridge gourd and bitter gourd was studied under laboratory conditions during August-September, 2000. The duration of life cycle of fruit fly was longer on bitter gourd as compared to ridge gourd . The length and breath of fruit fly was higher on bitter gourd as compared to ridge gourd . The fecundity rate of females field was higher on bitter gourd (33.66 61.25) as compared to ridge gourd (226.40 32.89) days.

Key words : Fruit fly, life cycle, ridge gourd, bitter gourd.

The fruit fly, *Dacus cucurbita* Coquillett is a notable pest of cucurbitaceous vegetables. The fly has been found to cause losses ranging from 50 to 72 per cent (Lall and Sinha, 1959; Kushwaha *et al.*, 1973 and Singh *et al, 1977)* to different cucurbits. The maggots of the fly cause extensive damage to fruits and make them unfit for human consumption.

Since the biology of the pest on different hosts differ greatly and sufficient knowledge about the biology of a particular insect pest in necessary for its management. Cucurbits being the main vegetable crop of semi-arid region of Rajasthan comparative of cucurbit fruit fly was studied on ridge gourd and bitter gourd.

MATERIALS AND METHODS

To study comparative biology, the adults of fruit fly, *D. cucurbitae* were collected from the field. The collected flies were released in separate glass jars (32 cm diameters x 30 cm length) containing fresh ridge gourd and bitter gourd fruits having blotting paper on the bottom of the jars. The jars were kept in the laboratory at ambient maximum temperature ranging from 28.70° C to 39.56°C with an average of 33.64°C, minimum temperature ranging from 20.96°C to 29.30°C with an average of 24.62°C and relative humidity varied from 57.0 to 90.20 per cent with an average of 73.6 percent. The observations were recorded on egg laying in the fruits daily. The egg laid fruits were transferred into new jars and kept under observations. The site of egg laying was identified by the presence of a drop of water like secretion which subsequently turned yellow like resinous mass and dried completely.

The eggs not disturbed till the larvae (maggots) hatched out. The newly hatched maggots were transferred individually with the help of fine camel's hair brush to fresh cut fruits in jars. Fresh fruit diet was provided daily until they pupated. The pupation took place in sand containing jars and pupae were transferred in the petridishes of 9 cm diameter. The petridishes were prepared by filling 0.75 cm thick layer of sieved sand at the bottom which was moistened and covered over with ordinary fitter paper, over which pupae were uniformly placed.

The observations on incubation period, larval period, larval instars, pupal period and adult emergence were thus recorded.

Microscope was used for recording the observations of hatching of eggs and detecting instars. For measuring the length and breadth of eggs and initial larval stages, ocular and stage micrometer were used.

The newly emerged pairs were transferred daily to new jars containing fresh ridge gourd and bitter gourd fruits for egg laying and to find out fecundity. The observations on pre-oviposition, oviposition, post-oviposition, life span of adults and fecundity were thus recorded.

RESULTS AND DISCUSSION

Egg

The fruit fly laid eggs singly or in clusters of 8-15 at a depth of 1 to 3 mm under the rind of ridge ground and bitter ground fruits by means of extensile ovipositor. Similar observation were also reported by Renjhen (1949). The freshly laid eggs were white in colour, slightly curved, elongated and tapered toward either end. Lall and Singh (1969) and Shivarkar and Dumber (1985) reported similar type of structure of eggs, support the present finding. The incubation period ranged from 1 to 2 days with a mean of 1.40 ± 0.27 days on ridge ground and 1 to 2 days with a mean of 1.33 ± 0.32 days on bitter gourd (Table -1). The present finding corroborates with those of Lall and Singh (1969), Shivarkar and Dumber (1985) and Samalo *et al.* (1991) who found incubation period ranging from 1.00 to 1.31 days.

The length and breadth of eggs varied from 0.95 to 1.01 mm and 0.18 to 0.22 mm with an average of 0.98±0.03 and 0.20±0.02mm, respectively, on ridge gourd and 0.97 to 1.08 mm and 0.20 to 0.23 mm with an average of 1.02 ± 0.03 mm and 0.22±0.1 mm, respectively, on bitter gourd (Table 2). These results are in agreement with that of Lall and Singh (1969) and Shivarkar and Dumbre (1985).

The egg laid per female ranged from 150 to 300 with mean of 226.4±32.89 on ridge gourd and 250 to 430 with a mean of 338.66±61.25 on bitter gourd (Table 3). The present observations are in agreement with that of Koul and Bhagat (1994 and Doharey and Butani 1986).

Larva (maggot)

The freshly emerged maggots were transparent and white in colour. Similar colour was reported by Lall and Singh (1969). The duration of first instar maggot varied from 1 to 3 days with an average of 2.00 ±0.82 days on ridge gourd and to 2 to 3 days an average of 2.16± 0.41 days on bitter gourd (Table 1). The present finding corroborates with that of Shivarkar and Doumbre (1985). The length and breadth of first instar maggot measured from 1.00

to 1.50 mm with an average of 1.31 ± 0.22 and 0.22 to 0.40 mm with a mean of 0.31±0.05 mm, respectively on ridge gourd and 1.00 to 1.70 mm with an average of 1.33±0.23 mm and 0.22 to 0.44 mm with a mean of 0.33±0.06mm, respectively on bitter gourd (Table 2).

The second instar maggots were transparent and elongated. The duration of this instar maggot varied from 1 to 2 days with a mean of 1.46±0.38 days on ridged gourd and 2-3 days with a mean of 2.33±00.52 days on bitter gourd (Table 1). Shivarkar and Dumbre (1985) and Patel and Patel (1998), support the present results. The second instar maggots measured from 4.00 to 4.90 mm in length with an average of 4.51±0.28 mm and 1.05 to 1.40 mm in breadth with a mean of 1.26±0.12 mm on ridge gourd and 4.00 to 4.99 mm in length with an average of 4.47±0.33 mm and 1.05 to 1.42 mm in breadth with a mean of 1.23±0.13 mm on bitter gourd (Table 2). The third instar maggots were creamy white in colour, body pointed to one end and broader at the other end having peculiar habit of jumping. Similar morphological characteristics were reported by Shivarkar and Dumbre (1985), supports the finding. The duration of third instar maggot lasted for 2 to 3 days with an average of 2.60±0.37 days on ridge gourd and 3 to 4 days with an average of 3.25±0.05 days on bitter gourd (Table 1). The present work is in agreement with that of Shivarkar and dumbre (1985). The third instar maggots measured 7.50 to 9.20 mm in length with a mean of 8.27±0.49 mm and 1.80 to 2.20 mm in breadth with an average of 2.03±0 .13 mm ridge gourd and 7.50 to 9.22 mm in length with a mean of 8.30±60 mm and 1.80 to 2.20 mm in breadth with an average of 2.00±0.15 mm on bitter gourd (Table 2). Similar observations were recorded by Lall and Singh (1969).

Pupa

The pupation tool place in the soil at the depth of 5 to 7 cm in the glass hars. Shivarkar and Dumbre (1985) support the findings. The pupa was barrel shaped and had a single black dot on posterior portion. Similar observations were recorded by Lall and Singh (1969). The pupal period ranged form 6 to 8 days with an average of 6.86± 0.61 days on ridge gourd and 6 to 9 days with an average of 8.03±1.40 days on bitter gourd (Table 1). The present results are in agreement with those of Lall and Singh (1969), Doharey (1983), Shivarkar and Dumbre (1985) and Samalo *et al.* (1991). The size of pupae measured from 4.00 to 6.00 mm in length with a mean of 5.23±0.65mm and 1.65 to 2.20mm in breadth with a average of 2.53±0.01 mm on ridge gourd and 5.00 to 6.50 mm in length with a mean of 6.21 ± 0.28 mm and 2.51 to 2.54 mm in breadth with an average of 251±0.01 mm on bitter gourd (Table 2). The present observation corroborates with that of Lall and Singh (1969).

Adult

The males were smaller than females. The male flies measured 6.60 to 7.80 mm in length with a mean of 7.32±0.35 mm and 9.10 to 10.20 mm in breadth with an average of 9.82±0.35 mm on ridage gourd and 6.70 to 7.80 mm in length with a mean of 7.35±0.40 mm and 9.20 to 19.30 mm in breadth with an average of 9.84±0.38 m on bitter gourd (Table 2). Lall and Singh (1969) support the findings.

Table 1. Biological parameters of fruit fly, *Dacus cucurbitae* on ridge gourd and bitter gourd

S. No	Stage (Duration (Days)	Ridge gourd		Bitter gourd	
		Range	Av.±S.D.	Range	Av.±S.D.
1.	Incubation period	1-2	1-40±0.27	1-2	133±0.32
2.	Larval period				
	I. Instar	1-3	2.00±0.82	2.3	2.16±0.41
	II. Instar	1-2	1.46±0.38	2-3	2.33±0.52
	III. Instar	2-3	2.60±0.37	3-4	3.25±0.50
	Total larval period	4-7	5.86±0.95	4-8	6.06±1.18
3.	Pupal period	6-8	6.86±0.61	6-9	8.03±1.40
4.	Adult longevity				
	Male	7-6	7.80±0.74	5-18	12.15±33.84
	Famale	16.-19	17.33±1.13	6-25	15.12±6.27
	Total life cycle				
	Male	11-18	14.52±2.36	17-21	19.05±1.43
	Female	17-21	19.05±1.40	17-23	19.98±2.00

* Mean of 15 individuals of each stage.

Table 2. Measurement of different stages of fruit fly, *Dacus cucurbitae*

Stage			Ridge gourd		Bitter gourd	
			Range	Av.±S.D.	Range	Av.±S.D.
Egg		R.G.	0.95-1.01	0.98±0.03	0.18-0.22	0.20±0.02
		B.G.	0.97-1.08	1.02±0.03	0.20-0.23	0.22±0.01
Maggot						
	I. Instar	R.G.	1.0-1.50	1.31±0.22	0.22-0.40	0.31±0.05
	II. Instar	R.G.	4.0-4.90	4.51±0.28	1.05-1.40	1.26±0.12
		B.G.	4.0-4.90	4.47±0.33	1.05-1.42	1.23±0.13
	III. Instar	R.G.	7.50-9.20	8.27±0.49	1.80-2.20	2.03±0.13
		B.G.	7.50-9.22	8.30±0.60	1.80-2.20	2.00±0.15
Pupa		R.G.	4.0-6.0	5.23±0.65	1.65-2.20	1.95±0.27
		B.G.	5.0-6.50	6.21±0.28	2.51-2.54	2.53±0.01
Adult						
	Male	R.G.	6.60-7.80	7.32±0.35	9.10-10.20	9.82±0.35
		B.G.	6.70-7.80	7.35±0.40	9.20-10.30	9.84±0.38
	Female	R.G.	7.80-8.90	8.37±0.41	9.55-10.65	10.32±0.30
		B.G.	7.81-8.93	8.40±0.35	9.56-10.68	10.35±0.35

Table 3. Pre-oviposition, oviposition, post-oviposition periods and fecundity of fruit fly, *Dacus cucubita*

Particulars	Ridge gourd		Bitter gourd	
	Range	Av.±S.D.	Range	Av.±S.D.
1. Pre-oviposition period (days)	9-11	9.66±0.56	10-13	10-83±0.80
2. Oviposition period (days)	2-2.5	2.26±0.24	2-3	2.34±0.26
3. Post-oviposition period (days)	5-6	5.36±0.49	4-5	4.52±1.58
4. Fecundity	150-300	226.4±32.89	250-430	338.66±61.25

*Mena of 15 individuals.

The longevity of males varied from 7 to 9 days with a mean of 7.8±0.74 days on ridge gourd and 5 to 18 days with a mean of 12.15±3.84 days on bitter gourd (Table 1). Shivarkar and Dumbre (1985) support the present results.

The longevity of female files ranged from 16 to 19 days with an average of 17.33±1.13 days on ridage gourd and 6 to 25 days with an average of 15.12±6.27 days on bitter gourd (Table 1). Shivarkar and Dumbre (1985) and Koul and Bhagat) (1994) support present findings.

The pre-oviposition period ranged from 9-11 days with an average of 9.66±0.56 days on ridge gourd and 10-13 days with an average of 10.83±0.80 days on bitter gourd (Table 3). The present findings are in agreement with those of Doharey (1983), Shivarkar and Dumbre (1985) and Doharey and Butani (1986).

The oviposition period was short and varied from 2 to 2.5 days with a mean of 2.26±0.24 days on ridge gourd and 2 to 3 days with an average of 2.34 ± 0.26 days on bitter gourd (Table 3). Shivarkar and Dumbre (1985) found oviposition period of 2.33 days support the present finding. The duration of post-oviposition period ranged from 5 to 6 days with a mean of 5.46±0.49 days on ridge and 4 to 5 days with an average of 4.52±1.68 days on bitter ground (Table 3). The duration of life cycle of fruit fly was longer on bitter gourd as compared to ridge gourd. The fecundity rate of famale flies was higher on bitter gourd.

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STORAGE RESPONSE OF DIFFERENT CULTIVARS OF BRINJAL (*SOLANUM MELONGENA* L.) UNDER AMBIENT CONDITIONS

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ABSTRACT

A storage study was conducted with ten cultivars of brinjal released by IARI, New Delhi. Fruits were harvested at optimum maturity stage and stored under ambient conditions (17.8-25.2° and 53-69% RH) to study the storage behaviour. Based on physiological loss in weight (PLW %), and /or sensory evaluation, maximum shelf-life of 6 days was observed in cultivars Pusa Hybrid-6, Pusa Hybrid-9, Pusa Uttam, Pusa Upkar, Pusa Bindu, Pusa Kranti and Pusa Purple Cluster, whereas Pusa hybrid-5, Pusa Purple Long and Pusa Ankur had a shelf-life of 4 days only. Absorbance value for anthocyanin content increased during storage, whereas texture and total phenols decreased.

Key words : Binjal, shelf-life, anthocyanin, texture phenols, PLW.

Brinjal or egg plant (*Solanum melongena* L.) is one of the most common and popular vegetable crops grown in India. A number of cultivars are grown in different parts of the country depending upon their yield potential and consumer preference based on certain characters *viz.* colour, size and shape of the fruit. To meet the demand of urban markets, a large quantity of brinjal comes from distant place where climatic conditions are favourable to grow more than on crop in a year. Cultivars which can withstand long distance transport and have long shelf-life fetch a good price. Though a large number of cultivars are available in India, they have not been properly evaluated for their post harvest behaviour.

Keeping this in view, the present investigation was conducted to study the storage behaviour of ten cultivars of brinjal released by the Indian Agricultural Research Institute, New Delhi.

MATERIALS AND METHODS

Ten cultivars of brinjal viz., Pusa Hybrid-5, Pusa Hybrid-6, Pusa Hybrid-9, Pusa Uttam, Pusa Upkar, Pusa Purple Long, Pusa Ankur, Pusa Bindu, Pusa Kranti and Pusa Purple cluster were grown at research farm of the Division of Vegetable Crop, IARI, New Delhi, during autumn - winter season (1999-2000). Fruits were harvested at optimum maturity stage and kept in perforated plastic crates under ambient conditions where average daily temperature varied from 17.8to 25.2°C and relative humidity from 53 to 69%. Determination of PLW and sensory evaluation were done on alternate days. Post storage sensory evaluation (grading) was done in a four point scale with score from 1.0 to 4.0 as described by Gadakh *et al.* (1990) with slight modification. Shelf-life was determined on the basis of PLW (≥10%) and/or visual observations (score 2.0) whichever occurred first. Fruit texture (Compression force by Instron Universal Testing Machine), anthocyanin (Nothman, 1976) and total phenols (AOAC, 1970) were determined at starting and at termination of the experiment. Data on PLW were analysed as per the procedure of factorial completely randomised design and for the texture, anthocyanin and total phenols paired t-test was done.

RESULTS AND DISCUSSION

Physiological loss in weight (PLW)

On 8th day of storage, minimum weight loss (10.27%) was recorded in Pusa Uttam which was followed by Pusa Hybrid-

Table 1. Physiological loss in weight (%) of brinjal fruits stored under ambient conditions

Cultivar	PLW (%) on days of storage				
	2	4	6	8	Mean
Pusa Hybrid-5	3.47	10.33	13.83	17.76	11.34
	(3.14	(15.86)	(27.67)	(26.47)	(18.28)
Pusa Hybrid-6	2.48	5.63	8.13	10.43	6.67
	(2.25)	(8.64)	(16.26)	(15.55)	(10.67)
Pusa Hybrid-9	2.33	5.33	8.53	10.56	6.69
	(2.11)	(8.23)	(17.06)	(15.75)	(10.79)
Pusa Uttam	2.15	2.53	8.05	10.27	6.46
	(1.94)	(8.22)	(16.11)	(15.31)	(10.40)
Pusa Upkar	2.41	5.85	8.47	10.89	6.90
	(2.18)	(8.98)	(16.94)	(16.24)	(11.08)
Pua Ankur	4.10	9.01	13.89	16.79	10.95
	(3.71)	(13.84)	(27.78)	(25.03)	(17.59)
Pusa Purple Long	4.52	10.72	14.72	16.54	11.62
	(4.09)	(16.46)	(29.45)	(24.65)	(18.66)
Pusa Bindu	2.52	7.07	11.23	12.20	8.23
	(2.28)	(10.86)	(22.47)	(18.04)	(13.41)
Pusa Kranti	2.37	5.32	8.63	10.70	6.77
	(2.140	(8.18)	(17.26)	(16.40)	(10.90)
Pusa Purple Cluster	4.00	5.70	10.08	11.07	7.74
	(3.70)	(8.78)	(20.17)	(16.50)	(12.29)
Mean	3.05	7.04	10.56	12.72	
	(2.75)	(10.80)	(21.12)	(18.9)	
C.D. at 5%	Cultivar = 0.61; Days = 0.38; Cultivars x Days = 161.				

6 (10.43%), and Pusa Hybrid-9 (10.53%), respectively, and there was no significant difference among them, whereas, maximum weight loss was observed in Pusa Hybrid-5 (17.76%). Cultivars like Pusa Hybrid-5, Pusa Ankur and Pusa purple Long lost approximately 10% moisture on 4th days of storage which was considered as the end of shelf-life. Pusa Bindu and Pusa purple Culster lost 10% on the 6th of storage. This variation in weight loss in different cultivars might be due to inherent characters of fruit such as skin thickness, size and number of lenticels present on the surface, presence of waxy layer on the skin etc.. which had contributory effect on rage of transpiration and respiration (Singh *et al.*, 1989; Gadakh *et al.*, 1990).

Sensory

In general, on the 8th day of storage, all the cultivars reached grade 1.0 (poor). On 2nd day of storage the maximum score of 4.0 (excellent) was exhibited only by Pusa Uttam and Pusa Upkar. Similarly, on 4th day also both of these cultivars obtained maximum score (3.0 i.e. good). On the 6th day of storage, cultivars *viz.* Pusa Uttam, Pusa Ankur and Pusa purple Cluster recorded a score of 2.0 (fair) while, the remaining cultivars scored less than 2.0 (Table 2). The difference in the sensory evaluation score among the cultivars were because of shrivelling of fruits caused mainly due to the loss of moisture.

Shelf -life

Based on PLW and sensory evaluation it was found that cultivars Pusa Hybrid-5, Pusa Purple Long Pusa Ankur had a shelf-life of 4 days, whereas the remaining cultivars had 6 days of shelf-life.

Texture, anthocyanin and total phenols

For these characters, a high t-value was observed which that the observation before and storage has significant difference between them (Tables 3a & 3b). It was also

Table 2. Sensory evaluation of brinjal fruits stored under ambient conditions

	PLW (%) on days of storage				
Cultivar	2	4	6	8	Mean
Pusa Hybrid-5	4.00	3.11	2.16	1.00	1.00
Pusa Hybrid-6	4.00	3.73	2.66	150	1.00
Pusa Hybrid-9	4.00	3.11	2.77	1.77	1.00
Pusa Uttam	4.00	4.00	3.00	2.00	1.00
Pusa Upkar	4.00	4.00	3.00	1.66	1.00
Pua Ankur	4.00	3.00	2.66	2.00	1.00
Pusa Purple Long	4.00	2.22	1.66	1.00	1.00
Pusa Bindu	4.00	3.77	2.77	1.72	1.00
Pusa Kranti	4.00	3.88	2.66	1.80	1.00
Pusa Purple Cluster	4.00	3.77	3.22	1.00	1.00

4.00 : Excellent; 3.00 : Good; 2.00; Fair; 1.00 : Poor

Table 3a. Changes in total phenols, anthocyanin content and texture under storage

(mg/100g)	Pheonols		Anthocyanin		Texture (N)	
Cultivar	Before storage	After storage	Before storage	After storage	Before storage	After storage
Pusa Hybrid-5	52.75	20.35	0.050	0.337	74.69	33.36
Pusa Hybrid-6	64.05	27.20	0.039	0.225	62.78	18.53
Pusa Hybrid-9	60.60	45.80	0.037	0.282	54.76	21.48
Pusa Uttam	35.70	20.78	0.074	0.270	71.58	24.30
Pusa Upkar	41.65	26.17	0.063	0.291	78.46	29.86
Pua Ankur	59.10	43.99	0.065	0.275	47.80	32.25
Pusa Purple Long	41.45	33.07	0.079	0.273	39.98	11.65
Pusa Bindu	54.20	31.49	0.087	0.340	71.13	44.65
Pusa Kranti	47.64	25.75	0.051	0.323	77.76	20.74
Pusa Purple Cluster	56.60	31.02	0.031	0.136	80.57	23.64

Table 3b. t-value of total phenols, anthocyanin contents and texture

	Total phenols	Anthocyanin	Texture
Initial Stage (Mean)	62.81	0.057	65.95
Final Stage (Mean)	30.41	0.274	26.05
Difference	32.40	0.216	39.89
t-value	9.25	13.06	9.21
r-value	0.72	0.59	0.37

observed that there was an increase in absorbance value for anthocyanin (O.D.) whereas i.e total phenols content and fruit texture value decreased, during storage. Increase in absorbance value for anthocyanin might be attributed to the loss of moisture from the skin of the fruits during storage which might have increase the concentration of anthocyanin. Decrease in total phenols during storage was also observed by Esteban *et al.* (1989) in brinjal. They explained that he change wad due to the activity of polyphenol oxidase. At the end of storage life, a decrease in texture value was noted which might be attributed to the advancing senescence and loss of metabolic substrates. Pectin degrading enzymes (polygalacturonase and pectin methylesterase) may also be responsible for the degradation in fruit texture.

On the basis of the present study, Pusa hybrid-5, Pusa-Ankur and Pusa purple Long can be recommended for local markets involving short distance transport, whereas other cultivars can be suggested for long distance markets owing to their longer shelf-life.

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RESPONSE OF PACLOBUTRAZOLAND MALIC HYBRAZIDE ON GROWTH, FLOWERING-FRUITING AND YIELD OF BITTERGOURD CV. MEGHALAYA LOCAL

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Nine treatments of plant growth regulators (PGR's) namely paclobutrazol and malic hydrazide were given in bittergourd at two true leaf stage as soil drenching around the plant. Among the PGR's, paclobutrazol 100 mg/l and malic hydrazide 2000 mg/l were found the best treatments for increasing yield and may be used for yield improvement of Megalaya Local cultivar of bittergourd. The paclobutrazol 100 mg/l gave 21.68 per cent more yield than 200 mg/l of malic hydrazide.

Key words : Paclobutrasol, malic hydrazide, gibberellin biosyntesis, sink-source relationship.

In general bittergourd varieties bears high male and female sex ratio almost throughout India, which causes low production with less economic return. Fluctuating environment of Umiam is major cause for enhancing number of male flowers and suppressing female flowers in bittergourd. Exogenous application of plant growth regulators PGR's have been extensively tested for increasing number of vines, altering the sequence of flowering and sex ratio with higher yield of cucurbitaceous fruits including bittergourd. Therefore, the present experiment was laid out to standardize the suitable concentration of paclobutrazol and malic hydrazide to boost the yield of bittergourd in Umiam condition of Meghalaya.

MATERIALS AND MATHODS

An experiment was conducted on local variety of bittergourd during June, 2000- in RBD having three replications consisting of 20 plants in each replication at Horticultural Research Farm, ICAR Research Complex for NEH Region, Umiam Meghalaya. Seven concentrations viz, 50, 75, 100, 125, 175 and 200 mg/l of paclobutrazol and two concentrations (100 X 200 mg/l) of malic hydrazide were given ad drenching around the plant at two true leaf stage. The water treated plants were considered as control. The observations on growth, flowering-fruiting and yield were recorded from randomly selected ten plants from each treatment in each replication. The data obtained were subjected to statistical analysis, described by Panse and Sukhatme (1989).

RESULTS AND DISCUSSION

Data presented in Table 1 showed that

all the PGR's significantly reduced vine length and internode length whereas, increased side branches and leaves/plant as compare to water treated control. Maximum reduction in vine length and internode length were recorded in 200 mg/l of paclobutrazol followed by 175 mg/l. Both treatments did not differ statistically among themselves in reduction of vine and internode length.

In malic hydrazide treatment, the higher concentration caused maximum reduction but statistically at par with their lower concentrations. In spite of reduction in vegetative growth, 100 mg/l paclobutrazol and 200 mg/q malic hydrazide caused maximum number of side branches and leaves/plant. The reduction in vine and internode length in present investigation may be due gibberellin biosynthesis. On the other hand, increase in side branches and number of leaves/plant by both PGR's in present finding might be due to release of auxiliary buds from apical dominance. A peculiar observation in present finding appeared that as the paclobutrazol concentration increase, it caused detrimental effect in respect to vegetative growth which may be due to disruption of metabolism in plants as well as increase of inorganic phosphate. Poor

Table 1. Effect of paclobutrazol and malic hydrazide on vine length, internode length, side branches and number of leaves of bittergorud Cv. Megalaya Local

Treatments	Vine length (cm)	Internode length (cm)	Side branches/plant	Leaves/plant
Paclobutrazol 50 mg/l	188.33	5.66	14.67	49.33
Paclobutrazol 75 mg/l	138.33	5.10	15.33	74
Paclobutrazol 100 mg/l	179.66	4.80	22.67	87.33
Paclobutrazol 125 mg/l	131.66	4.16	11.33	62.66
Paclobutrazol 150 mg/l	107	3.46	6.66	36.33
Paclobutrazol 175 mg/l	80	3.23	4	33.67
Paclobutrazol 200 mg/l	72.33	2.96	6.33	38
Malic hydrazide 100 mg/l	146.33	6.3	9	57.66
Malic hydrazide 200 mg/l	143.33	5.66	11.33	64
Water treated (control)	245	7.90	6	44.33
C.D. at 5%	34.93	1.19	3.83	9.97

vegetative growth and yield due to higher concentrations of paclobutazol were also recorded by El-Sayed (1991) in vegetable like snap bean which is in consonance with our findings.

Node at which first female flower appeared is an indication of sex modification as well as increase in yield by application of PGR's. Data in Table 2 revealed that among paclobutrazol treatments, 200 mg/l caused appearance of female flower at nearest node and 100 mg/l increase female flowers, number of fruits and total yield. Paclobutrazol 100 mg/l and onwards as well as higher concentration of malic hydrazide significantly caused early picking of fruits. These treatments were statistically at par. It was also calculated that 100 mg/l of paclobutrazol gave 21.68 per cent more yield than 200 mg.l if malic hydrazide. It was also found that 100 mg/l onward concentrations of paclobutrazol caused detrimental effect on yield and its contributing characters. Increase in pistillate flowers, number of fruits and yield due to PGR's in present finding may be due to inhibition of

Table 2. Effect of paclobutrazol and malic hydrazide on node female flower appeared, number of female flowers, fruits/plant, days to first picking and yield if bittergourd Cv. Maghalaya Local

Treatments	Node at which female flower appeared	Female flowers/plant	Fruits/plant	Days to first picking	Yield/plant (kg)
Paclobutrazol 50 mg/l	12	45	22.33	63	2.81
Paclobutrazol 75 mg/l	10	57.67	30.67	62	3.81
Paclobutrazol 100 mg/l	7.66	72.33	38.66	53.33	4.89
Paclobutrazol 125 mg/l	8.66	61.66	30.66	50.67	3.48
Paclobutrazol 150 mg/l	5.66	41	24	51.66	3.13
Paclobutrazol 175 mg/l	5.66	36.66	29.66	51.66	3.20
Paclobutrazol 200 mg/l	3.66	35.66	18.33	57	2.26
Malic hydrazide 100 mg/l	6.67	55	21.66	61	2.40
Malic hydrazide 200 mg/l	6	56	29	55.33	3.83
Water treated (control)	13	42.67	20	69	2.51
C.D. at 5%	1.59	9.50	4.85	4.89	0.69

GA biosynthesis which changes sink-source relationship by reallocating the carbohydrate sources towards the other organs. Appearance of pistillate flower on nearest node by higher concentration of paclobtrazol may be due to shorting of vine and internode length and poor response on yield due to poor vegetative growth and burring of leaves. Superior effect of paclobutrazol and malic hydrazide for increasing yield have also been reported in cucurbits like summer squash (Aroroa *et al.* 1989) and bottleground (Mishra *et al.* 1972), respectively. On the basis of results it can be concluded that 100 mg/l paclobutrazol and 200 mg/l malic hydrazide may be used for increasing yield of bittergourd Cv. Meghalaya Local.

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EFFECT OF WEED MANAGEMENT PRACTICES ON THE NUTRIENT UPTAKE OF BANANA AND ITS ASSOCIATED WEEDS UNDER FOOT HILLS OF NAGALAND

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ABSTRACT

A field experiment was conducted to study the effect of weed management practices and the crop-weed competition for nutrient on banana and its associated weeds. Results showed that all weed control measures markedly reduced the weed infestation (WCE 41.74-88.81%) compared to control during both years. Black polythene mulch was found the most effective weed control measure. The weed removed on average 92.89, 20.45 and 22.37 kg N, P_2O_5 and K_2O/ha, respectively from the unweeded plot. Weed caused considerable reduction in the nutrient uptake by the banana plants and reduced the yield. The uptake of nutrients and yields of banana were significant under black polythene mulch followed by hand weeding treatments as compared to control during both years.

Key words : Banana, nutrient uptake, weed management practices.

Banana, being long duration crop coupled with wider row planting and slow initial growth allows weeds to compete for nutrients at early growth stage. The nutrient availability and uptake by plants have a greater role in the crop-weed competition. Yield losses due to season long weed competition in banana have been reported in the tune of 40-70-% (Singh and Uma, 1997) depending upon the type of weed flora and their intensity, stage nature and duration of crop-weed competition. Weeds utilized considerable amounts of nutrients. About 30-40% of the applied nutrients are reported to be utilized by weeds for their nutrient uptake in field crop and weeds growth and development (Dryden and Krishna Moorty, 1997). Effective weed management practices increase the uptake of nutrients by crop and decrease the removal through weeds. For maximizing the crop production, the depletion of soil nutrients by weeds should be effectively checked otherwise the precious fertilizer applied to the crop will be usurped away by the weeds. The present paper aims to find-out the crop-weed competition for nutrients and the resultant effect on the banana production under foot-hills of Nagaland.

MATERIALS AND METHODS

The field experiment was carried out at ICAR Research Complex for NEH Region Nagaland Centre, Jharnapani during 1998-99 and 1999-200 in the sandy loam soil acidic in reaction (pH 5.60), low in available N, medium in available P and available K. The experiment was laid out in a randomized block design with 8 treatments replicated thrice. A uniform 15 cm thick mulches viz. paddy straw and banana trash, black polythene, 50µ thickness, hand weeding, glyphosate (3ml/l) and inter cropping systems i.e. banana+french bean and banana+cowpea were compared against control.

Black polythene mulch was applied by cutting the polythene film according to required size and laid over the pots. Paddy straw and banana trash, all 20 kg weight were applied after planting. French bean var. 'Contender' and cowpea var. 'Pusa Komal' were intercropped on the same piece of land. Uniform suckers of banana cv. 'Jahajee' were planted in the month of June, during both years at 2 m x 2 m. Recommended rates of fertilizers and other cultural practices were followed to all the treatments uniformly.

Crop and weed samples were collected at harvesting stage of crop in each case, oven dried, till constant weight was obtained. The samples were powdered and the analysis for N, P_2O_5 and K_2O were made following the standard analytical procedures modified Kjeldah's method, vanado molybdophosphoric acid yellow colour method (Page *et al.*, 1982) and flame photometric method for N, P_2O_5 and K_2O, respectively.

RESULTS AND DISCUSSION

Weed flora

On an average the weed flora of the experimental field at harvesting stage comprised of 22% grasses, 48% sedges and 30% broad leaf weeds in 1999 and 35% grasses, 23% sedges and 42% broad leaf weeds in 2000. The major weeds observed in banana field were *Cynodon dactylon* L., *Cyperus rotundus* L., *Parthenium hysterophorus, Chenopodium album* Linn., *Sonchus arnensis, Brachiaria septans, Mint spp.* and *Euphorbia spp.*

Effect on weeds

Weed population, weed dry weight and weed control efficiency has been presented in Table 1. Results showed that all weed control treatments significantly reduced the total weed population and weed dry weight compared to control during both years. The lowest total weed counts/m^2 and dry weight were recorded under black polythene mulching followed by hand weeding and paddy straw mulch. The total weed population recorded under this treatment was significantly lower than all weed control treatments. Mulching excludes sunlight and inhibits top growth. It also provides a barrier for emerging weeds (Rao, 1983) and thus has post-emergence weed control efficiency. Weed control efficiency of different treatments varied 40.64-87.09 during 1999 and 42.50-98.53 during 2000. The highest weed control efficiency (87.09-

90.53%) was recorded with the use of black polythene mulch. However, hand weeding was also comparable (WCE 61.71-63.10%) to this parameter. This observation revealed that the uptake of nutrients viz., nitrogen phosphorus and potassium by the weeds was significantly higher in weedy check (91.58-94.21, 19.52-21.36 and 21.56-23.15 kg N,P_2O_5 and K_2O/ha, respectively, while the lower uptake of N, P_2O_5 and K_2O was obtained with black polythene mulching followed by hand weeding during both the years of experimental period. In general, the uptake of these nutrients by weeds was low with treatments involving pre-emergence application of black polythene mulching and post-emergence application of paddy straw and banana trash mulching treatments (Table 1).

The uptake of nitrogen, phosphorus and potassium by banana under different weed control treatments varied significantly during both years. The uptake of nitrogen by different treatment increased form 2.34.58 kg/ha to 352.34 kg/ha during first year and from 234.73 kg/ha to 367.42 kg/ha during second years. Highest uptake of N was recorded by banana plants under black polythene followed by paddy straw, banana trash and hand weeding treatments as compared to control. It might be due to solarization effect as advocated by Kumar and Yaduraju (1992). The uptake of N by banana inter cropped with french bean and cowpea slightly increased as compared to weedy check. This increased N uptake by the principal crop raised with legumes might be attributed to the substantial role of legume component with respect of N towards the crop. The data revealed that the uptake of phosphorus was maximum with paddy straw followed by banana trash and black polythene mulching treatments. In most of these cases, the uptake of phosphorus by the crop has been observed. Mulching treatments as a result of their decomposition might have increased the solubility of phosphorus which was utilized by the plants thereby sowing higher values. All treatments showed positive response with respect to

Table 1. Effect of weed management practices on weed population, weed dry weight and weed control efficiency

Treatment	No. of weed/m^2		Weed dry weight (g/m^2)		Weed control efficiency (%)	
	1999	2000	1999	2000	1999	2000
Hard weeding	130.14	126.83	102.83	95.79	61.71	63.10
Banana trash	165.16	154.67	131.72	114.97	50.93	55.71
Paddy straw	134.32	128.41	129.35	115.34	51.82	57.67
Black polythene	26.56	23.79	34.67	24.65	87.09	90.53
Banana+french bean	174.06	169.04	158.48	149.28	40.97	42.50
Banana+cowpea	181.63	176.17	160.57	143.74	40.64	43.73
Glyphosate (3ml/l)	157.06	151.07	127.37	113.08	52.56	56.44
Control	397.61	376.57	268.47	259.60	-	-
C.D. at 5%	21.73	19.58	14.56	14.69	-	-

Table 2. Nutrient removal by weeds, nutrient uptake and yield of banana

Treatment	Uptake by weeds (kg/ha)						Uptake by banana						Yield (kg/bunch)	
	N		P_2O_5		K_2O		N		P_2O_5		K_2O			
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Hard weeding	10.34	11.06	1.97	1.81	3.79	4.09	286.73	291.07	38.15	38.47	702.81	712.76	16.02	17.28
Banana trash	10.44	11.28	2.47	2.39	3.82	4.36	316.44	327.12	41.45	43.23	863.14	871.23	13.39	15.31
Paddy straw	11.30	11.75	2.13	2.02	4.38	4.81	328.41	336.21	46.71	46.74	984.77	986.13	13.40	10.05
Black polythene	8.46	8.34	1.64	1.55	3.43	4.13	352.34	367.42	38.15	41.05	693.26	707.35	16.25	17.83
Banana+French bean	14.58	15.70	4.38	4.06	4.87	5.47	247.25	251.46	34.63	35.06	745.32	749.04	11.66	12.68
Banana+cowpea	14.91	14.67	3.63	3.57	5.62	6.34	253.87	34.28	34.74	712.44	713.76	13.35	13.35	14.25
Glyphosate (3ml/1)	12.70	12.40	2.89	2.71	4.62	5.41	234.58	246.81	29.84	30.15	669.78	683.02	13.17	14.69
Control	91.58	94.21	19.52	21.36	21.54	23.15	114.23	121.04	21.36	23.63	353.71	361.22	9.84	11.06
C.D. at 5%	4.72	3.74	2.41	2.33	3.74	2.08	20.04	17.16	4.08	5.99	44.55	41.88	3.21	3.45

potash utilized by banana increased significantly as compared to control. Maximum uptake of potash was observed with paddy straw followed by banana wash and intercropped with legumes. Contrary to this, reduced uptake of potash by crop was recorded with black polythene mulching while it was at par with hand weeding and glyphosate. The higher uptake of potash by plant is directly associated with rapid decomposition of organic mulches.

Yields

Season long weed competition in banana reduced the yield by 82.69 and 47.84% during 1999 and 2000, respectively compared to the highest yield obtained under black polythene mulch. This may be attributed to variation in weed tensility during 1999 and 2000. Singh and Uma (1997) also reported 40 to 70 percent reduction in yield due to season long weed competition in banana. All the weed control measures (Table 2) proved effective in achieving significantly higher yield compared to weedy check. The highest yield was recorded under black polythene mulch during both the years. The increase in yield due to weed control measures might be the result of suppressing weed growth that rendered favourable conditions like increased availability of moisture and nutrient for proper development of crop. Hand weeding was the next best treatment. Increased yield by application of black polythene is in agreement with the findings of Srinivas and Hegde (1994) and Bhattacharya and Madhava Rao (1985) in banana.

Thus, it may be inferred from the observations tha the weed control practices markedly reduced weed density and weed infestation under foot-hill conditions of Nagaland. Mulching with black polythene and hand weeding would reduce the crop-weed competition in banana and help in obtaining higher yield.

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INFLUENCE OF VARIABLE POTASSIUM ON BARLEY METABOLISM

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ABSTRACT

Barley (*Hordeum vulgare* L.) cv. Azad was grown in refined sand at variable potassium raning from 0.05 to 16 mM. Both low (< 4mM) and high (> 4 mM) potassium depressed the growth and biomass of barley. Visible symptoms of potassium deficiency (< 4 mM) were intense chlorosis lager changing to necrosis, lesser tillers and reduced formation of inflorescence as a result seed yield was disturbed. The concentration of potassium increased with increase in potassium supply and decreased in upper parts of barley. In potassium deficient (<4 mM barley leaves the concentration of potassium, chlorophylls a and b, DNA and RNA and activity of catalase decreased and that of ATPase and peroxidase increased significant. In potassium deficient (< 4 mM) barley seeds concentration of protein nitrogen decreased and that of non-protein nitrogen, sugars and proline increased resulting in deteriorated quality of grains.

Key words : Barley, potassium, enzymes, sugars.

Potassium as a macronutrient is required directly or indirectly for several metabolic functions of plants in addition to being a quality element. Agricultural intensification, limited use of organic manure and repeated use of nitrogen and phosphorus fertilizers, high rate of potassium mobility in soil and plant systems are responsible for depletion of soil potassium resulting in a wide spread potassium deficiency in India Brar and Sekhon, 1985). Therefore, exogenous application of potassium is essential for increasing crop yield in India.

Potassium is most abundant cation in the cytoplasm and has an outstanding role in plant water relations (Hsio and Lauchli, 1986). Potassium is known to play a vital role in photosynthesis (Huber, 1985), translocation of photosynthates (Demmig and Gimmler, 1983) and activation of several enzymes (Reggiani *et al.*, 1993). In potassium deficiency the plants are more susceptible to frost damage, fungal attack and saline conditions. In such deficient plants, often an abnormal development of tissues or cell organelles and mitochondria in several plant species is dependent on the level of potassium present. Potassium has a beneficial role on photophosphorylation as well as photosynthetic O_2 production is stimulated by K^+. Thus potassium is involved in various metabolic pathways of plant system.

In this paper an effort has been made to describe the changes in growth, biomass economic yield and metabolism of barlety when gown at variable potassium in refined sand.

MATERIALS AND METHODS

Barley (*Hordeum vulgare* L.) cv. Azad was grown in refined sand (Agarwala and Chatterjee, 1996) in polyethylene containers of 5 L capacity at potassium levels ranging from acute deficiency to excess (0.05, 0.1, 0.5, 1, 4, 8 and 16 mM), supplied as potassium chloride. The composition of nutrient solution omitting potasium was as follows :

$NaNo_3$ 4mM; $Ca(NO3)_2$ 4mM; NaH2PO4 1.5mM; Fe Fe-EDTA 0.1mM; Nacl 0.1 mM; H3BO3 30 µM; MnSo4 10µM; $CuSO_4$ 1 µM; $ZnSO_4$ µM; $NaMoO_4$ 0.2µM; $CoSO_4$ 0.1µM; and $NiSO_4$ 0.1µM.

The nutrient solution was supplied daily except on Sundays when each pot was flushed with distilled water to remove deteterious substances from sand and root surface.

In each treatment there were replicates. Plant were maintained in culture till maturity in a glass house at an ambient temperature. In the beginning there were four plants in each pot later at maturity a single plant was maintained in each pot.

The contribution of potassium form purified sand, nutrient and water was <0.01 mM which was taken into consideration while supplying different levels of potassium.

A periodic record of visible symptoms of low (< 4mM), excess (> 4mM) potassium was made. The plants were sampled at 80 DAS (days after sowing) and oven dried for dry matter yield. Potassium was estimated in different plant parts after wet digestion in clear digest, using a systronics Flame Photometer Model 121. The concentration of chlorophyll, proline, sugars, protein nitrogen, nucleic acids and activities of catalase (Chatterjee *et al.*, 1988). ATPase and peroxidase (Mitra *et al.*, 1998) were measured in fresh tissue of middle leaves. The data were analysed statistically, taking a probability level of P =0.05 as being significance.

RESULTS AND DISCUSSION

At d 40, potassium deficiency effects initiated as depression in growth of barley a low potassium (<4mM) which became more pronounced at d 50-70.

The symptoms of low potassium in barley initiated as chlorosis from the leaf tip, became intense near margins and spread downward covering the interveinal area. Later necrotic spots appeared on the chlorotic areas, enlarged and coalesced to from parallel streaks. With persistent potassium deficiency at 0.05, 01 and 0.5 mM k, the lamina of old leaves became scorhed and necrotic giving the leaves a rugged appearance. Small brown spots developed on the interveinal areas might be due to accumulation of putresine (Tachimoto *et al.*, 1992). With acute and persistent potassium deficiency, the plants appeared bushy due to excess growth of axillary shoots from the base of the plants.

The visible potassium deficiency symptoms observed in barley are somewhat similar to those reported for plant species other than barley (Hewitt, 1983; Singh and Sharma, 1988).

The biomass and economic yield of

barley were highest at 4 mM potassium supply and compared to these, thy decreased at both low (<4mM) and excess (>4mM) potassium (Table 1). The decrease in biomass might be due to low protein synthesis or disturbed carbohydrate and nitrogen metabolisms in such conditions.

In pottassium deficient barley, the concentration of both reducing and non- reducing sugars increased might be due to either reduced rate of carbon assimilation (Mengel, 1985) or inadequate energy (ATP) supply (Mengel and Kirkby, 1987). The lowering of protein-N and an increment in non-protein nitrogen suggested a retardation in protein synthesis under low potassium conditions (Fig.1.) and are somewhat similar to the findings on sugarcane (Chatterjee *et al.*, 1998). The significant increase in proline concentration in potassium deficient barley leaves is similar to the reports on its accumulation in low potassium in crop plants other than barley. These observations might suggest an indirect role of potassium in maintaining protein levels as well as its synthesis (Ali *et al.,* 1987).

The reduced concentration of chlorophylls a and in potassium deficient barley leaves is in consonance with the results on some other plant species (Table 1). The reduction in chlorophyll concentration in turn disturbs photosynthesis and leaf growth.

The lowered concentration of both DNA and RNA in barley leaves is in agreement with earlier reportes on sugarcane (Chatterjee *et al.*, 1998) deficient in potassium (Table 1). The reduction in RNA concentration might be due to stimulated activity of ribonuclease in potassium barley leaves are consistent with

Table 1. Variable potassium and dry matter, infloresence yield , concentrations of potassium, chlorophyll and nucleic acids in barley leaves

	mMK							LSD
Parameters	0.05	0.1	0.5	1	4	8	16	(P=0.05)
Dry matter yield (g plant^{-1})	2.99	3.38	4.34	4.70	6.29	5.24	5.26	0.32
Inflorescence wt. (g plant $^{-1}$)	0.84	1.50	1.79	2.91	3.78	3.78	2.88	0.11
Leaf K (% dry matter)	0.88	1.05	2.12	2.13	5.47	7.95	10.2	1.24
Chlorophyll (mg g^{-1} fresh wt.)								
a	1.915	1.580	2.959	4.139	4.332	3.379	2.346	0.327
b	0.567	0.628	1.198	1.572	1.720	1.188	0.844	0.111
Nucleic acid (% fresh wt.)								
RNA	0.433	0.466	0.542	0.692	0.783	0.512	0.482	0.238
DNA	0.052	0.068	0.078	0.079	0.084	0.067	0.050	0.009

the findings on some other crop plants Chatterjee *et al.*, 1998) and might be due to reduced protein formation under such conditions. The low catalase activity might be due to low availability of iron which in turn is responsible for inducing Fe deficiency type of chlorosis in low potassium conditions (Marschner, 1995). In potassium deficient barley leaves the stimulated activity of peroxidase might be due to accumulation of phenols and is in accord with other reports (Mitra *et at.*, 1998) (Fig. 2.)

The concentration of potassium was higher in leaves (5.5%) (Table 1) than seeds (1.5%) (Fig. 1.) at adequate potassium level. This is in consonance with the results reported by Marchner (1995) for most plants. The accumulation of potassium in vegetative parts is dependent mainly on relatively high permeability of plant membranes to potassium and the bulk of potassium is mainly taken up during vegetative growth. The rate of potassium uptake is lowered with the development of reproductive parts as is observed in barley.

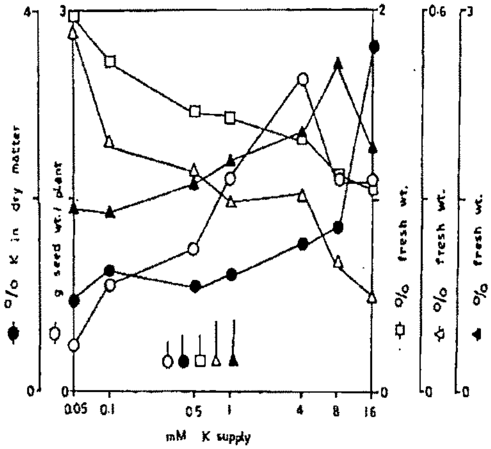

Fig. 1. Variable potassium and seed weight, concntrations of potassium, sugars, protein and non-protein nitrogen in barley seeds. Vertical lines represent LSD (P=0.05).

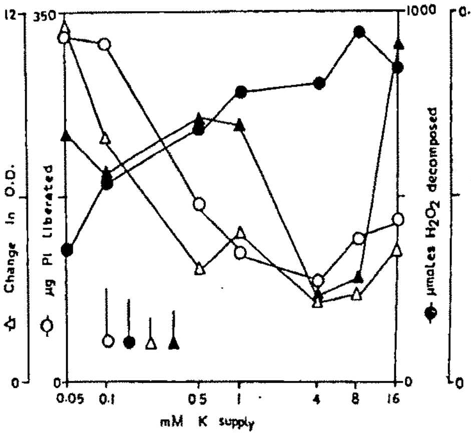

Fig. 2. Variable potassium and specific activities of ATPase, catalase, peroxidase and proline concentration in barley leaves. Vertical lines represent LSD (P=0.05).

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YIELD AND WATER USE EFFICIENCY OF PEARLMILLET AS INFLUENCED BY MOISTURE CONSERVATION METHODS UNDER RAINFED CONDITIONS

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ABSTRACT

A field experiment was conducted during *kharif* 1999 under rainfed conditions to study the effect of moisture conservation methods on yield and water use efficiency of pearlmillet. Organic mulch+kaolin spectacularly improved the overall development of the crop over the control. Moisture conservation with organic mulch + kaolin, dust mulch + kaolin and organic mulch alone helped to increase the yield and water efficiency of rainfed pearlmillet, due to scarce rainfall in the cropping season.

Key words : Moisture conservation, mulch, pearlmillet.

In rainfed areas, pearlmillet generally faces mid season drought resulting in lower yield. Till data, various workers have reported the favourable effect of soil moisture conservation methods (Gupta 1985) or prevention of moisture loss through the plant body (transpiration control) (Kumar *et al.* 1995 a). But the combination of these two has been less experimented upon. Hence the present experiment was carried out to determine the extent of the effect of moisture conservation on the yield as well as on the water use efficiency of pearlmillet.

MATERIALS AND METHODS

The field experiment was conducted during the *kharif* season of 1999 at the Indian Agricultural Research Institute, New Delhi. Treatments consisted of ten moisture conservation methods viz. T_1: uniform row spacing at 50 cm (URS), (control), T_2 : Paired row sowing at 30/70 cm (PRS), T_3 : PRS with open furrow in the wider row 15 days afrer sowing, T_4 : Ridgw and furrow (URS), T_5: Dust mulching (URS) : T_6 : Spraying of kaolin 6% as light reflectant (URS), T_7 : Organic mulch @ 5 (URS), T8 : Atrazine 100 ppm (URS), T_9 : Organic mulch + kaolin 6% (URS), T_{10} : Dust mulch + kaolin 6% (URS). The treatments were laid out in randomised block design with four replications. Hybrid bajra 'BK-560-230' was sown on 22 July, 1999 with uniform fertilizer dose of 40 kg N/ha and 30 kg K_2O/ha applied at the time of sowing.

The (300.2 mm) rainfall received during the crop growth period though not sufficient, was well distributed over the period. The crop experienced dry spell during the second fortnight of August. Hence, the moisture conservation measures were applied during that period. Two hand weedings were given uniformly to all plots in the fourth week and sixth week after sowing. The crop was harvested on the 28 September, 1999 with a crop growth period of about 66 days.

RESULTS AND DISCUSSION

Yield

The Yield was directly affected by the development of some parameters known as the yield attributing characters. These include number of ear heads per square meter, number of grains per ear head, grain weight per ear head and 1000-grain weight. All these characters were better developed in the treatment consisting of organic mulch + kaolin (T_9) (Table 1). These results are in close conformity with those of Gupta (1985), and Kaushik and Gautam (1994). Straw mulch created a physical barrier and cut off the solar radiation falling on the soil surface. This reduced the energy supply to the evaporating soil surface and thus reduced the evaporation loss. In addition, it facilitated high rate of nifiltration of the rain water because of less surface sealing by the falling rain drops and also due to retention of rain water for a longer period on the soil surface. It also reduced the soil temperature besides checking seedling mortality and improving the crop stand. Kaolin spray on the other hand reduced the transpiration loss by providing a reflective white coating on the leaves. The spry thus increased leaf albedo and reduced the total heat load on the leaves which ultimately resulted in minimization of transpiration loss.

Grain and stover yield increased significantly due to moisture conservation practice (Table 1). The treatment organic mulch+ kaolin spray recorded the highest grain and stover yield due to better development of yield attributing parameters. Dust mulch + kaolin spray, organic mulch and kaolin spray alone also resulted in better yield of grain and stover. Among the land configuration measures, ridge and furrow method proved more efficient in giving better yield. Similar results were also obtained by Kumar *et al* (1995b) and De *et al.* (1983).

Water use Efficiency (WUE) :

The organic mulch + kaolin gave the highest water use efficiency (65% more over control) which was significantly higher over most of the land configuration methods except ridge furrow and dust mulch treatment (Table 2). Other moisture conservation methods like kaolin spray, organic mulch alone and atrazine spray gave significantly better results than no moisture conservation measures (i.e. control). Among land configuration treatments, ridge and furrow proved to be the best. Water use efficiency which is the ratio of the grain yield to that of the evapotranspiration or the consumptive water use, is thus directly affected by both the grain yield and consumptive use of water. Water use efficiency will be inevitably increased if either the grain yield is increased or the consumptive use decreased or both can be achieved simultaneously. The consumptive use of water was least in the crop treated with organic mulch+kaolin as it checked both the evaporational as well as transpiration loss of water effectively. Under

Table 1. Effect of moisture conservation practices on yield attributes, grain and stover yield of pearlmillet

Treatment	No. of earrheads/m	No. of grains/ earhead	1000-grain weight(g)	Grain yield (q/ha)	Stover yield (q/ha)
T_1 : Uniform row sowing (URS)	56	1564	6.27	15.08	52.11
T_2 : Paried row sowing (PRS)	56	1587	6.41	17.61	52.17
T_3 : PRS with open furrows in wider rows	57	1600	6.47	17.28	52.22
T_4 : Ridge and furrow (URS)	58	1627	6.50	18.75	52.97
T_5:Dust mulching (URS)	56	1610	6.38	16.06	52.13
T_6 : Kaolin spray (URS)	60	1663	6.53	18.85	54.52
T_7 : Organic mulch (URS)	62	1670	6.60	19.60	54.97
T_8 : Atrazinc spray (URS)	61	1649	6.51	18.79	53.87
T_9 : Organic mulch + kaolin Spray (URS)	64	1727	6.78	21.93	56.94
T_{10} : Dust mulch + kaolin Spray (URS)	63	1676	6.60	19.33	54.62
C.D. at 5%	.34	83.50	0.39	3.174	2.407

Table 1. Effect of moisture conservation practices on (on water use efficiency) of pearlmillet

Treatment	Yield (q/ha)	Consumptive use (mm)	WUE (kg/ha mm)
T_1 : Uniform row sowing (URS)	15.08	272	5.54
T_2 : Paried row sowing (PRS)	17.16	261	6.68
T_3 : PRS with open furrows in wider rows	17.28	247	7.00
T_4 : Ridge and furrow (URS)	18.75	248	7.56
T_5:Dust mulching (URS)	16.06	269	5.98
T_6 : Kaolin spray (URS)	18.85	244	7.72
T_7 : Organic mulch (URS)	19.60	242	8.09
T_8 : Atrazinc spray (URS)	18.79	246	7.63
T_9 : Organic mulch + kaolin Spray (URS	21.93	237	9.16
T_{10} : Dust mulch + kaolin Spray (URS)	19.33	245	7.88
C.D. at 5%	3174	25.8	1.66

other treatments, only either of these tow is checked. Thus, the WUE was highest for the organic mulch + kaolin. All other moisture conservation practices except the paired row sowing (PRS) alone as well as PRS with furrows and dust mulch treatment brought about marked improvement in WUE by pearlmillet. Similar results have been reported by Gupta and Gupta (1985) and Daulay *et al* (1979). The superiority of the moisture conservation measures as against the control was more pronounced due to the insufficient rainfall received during the crop growth period.

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NITRIFICATION INHIBITION AS INFLUENCED BY ORGANIC ISOLATES FROM NON-EDIBLE OILSEED CAKES

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ABSTRACT

An incubation experiment was conducted during February to April 1998 on Typic Haplustept to study the comparative efficacy of organic isolates from non-edible oilseeds cakes on nitrification of applied urea. The organic isolates used were from *neem, sal, kusum and undi* cakes with 15 and 30 % level of applied urea (on weight basis). All the four isolates from non-edible oilseed cakes were found effective in inhibiting nitfification process of applied urea. Amongest the cakes, *neem* cake isolate was most effective in inhibiting nitrification process as compared to iolates of other cakes. As the incubation period increased the rate of nitrification was observed to be faster in control as compared to treatments with organic isolates. Ammoniacal nitrogen was maintained at higher level as compared to nitrate nitrogen in all four isolates upto fourth week of incubation at both 15 and 30% level of isolates. However, the inhibitory effect of nitrification i.e., the comparative higher content of ammoniacal nitrogen was still maintained (16.80 and 20.50 mg kg-1 NH_4^+-N) at 7th week in both the levels due to *neem* seed cake isolates as against 11.20 mg kg^{-1} in control.

Key words : Nitrification inhibition, non-edible oil seed cakes, urea.

Use of nitrogenous fertilizer has been one of the primary means in achieving the targets of food production. But the recovery of these fertilizer materials is generally low for most crops, especially in Indian soils because of faster nitrification and subsequent losses due to leaching down from the soil rhizosphere or as gaseous products into atmosphere.

Urea, as a dominating nitrogenous fertilizer when applied to soil is readily converted ultimately into nitrate through biochemical processes with the help of nitrobactors. The processes play a key role for nitrogen transformation in soil that governs its uptake by crop or its loss from the soil by converting urea into ammoniacal nitrogen, a relatively retainable cationic form but followed by into nitrate, a highly mobile anionic form. Consequently, a significant amount of nitrate and partially oxidised form of nitrogen are lost through the process of leaching, denitrification and other chemical reactions resulting into reduced supply of nitrogen during the growth period of the crops. However, nitrogen inhibitors of synthesised chemical compounds like nitrapyrin. AM, terrazole, ATC, sulpathiazole, DCD, guanylthiourea etc are reported to inhibit the process of nitrification because of toxicity to nitrifying bacteria is a whole (Goring, 1962 and Janert *et al,* 1968) and possible other adverse effect in the soil. Several non-synthetic organic materials as plant products like non-edible oilseed cakes have been tried and found to be also efficient nitrification inhibitors. A detailed investigation has been attempted for the degree of inhibition in nitrification of applied urea due to organic isolates from non-edible oilseeds cakes.

MATERIALS AND METHODS

An incubation study was conducted during February to April 1998 on typic Haplustept having sand 68.8 per cent, silt 16.1 per cent; clay 15.1 per cent (textural class sandy loam) pH (1:2.5, soil : water) 7.90, EC 0.42 ds m^{-1}, organic carbon 0.41 per cent : CEC 10.30 Cmol (P+) kg^{-1} and available N, P and K 252.0, 11.9 and 129.0 kg ha^{-1} respectively. The treatments constituted with 44.5 mg urea -4 kg^{-1} soil and organic isolates from each of four non-edible oilseed cakes *viz., neem sal kusum* and *undi* @ 15% and 30% of applied urea (weight basis). The treatment received basal application of 31.25 mg kg^{-1} soil for each of phosphorus (P_2O_5) and potassium (K_2O). The defatted oil cakes were extracted with aqueous solutions of ethanol, acetone, methanol and mixture of acetone and ethanol, respectively *neem, sal, kusum* and undi cakes with cake to extractant ratio 1:5. The extracts were dried on water bath and used as organic isolates.

Two hundred fifty grams of soil was taken in 400 ml capacity beaker and inoculated at 35°C with the different treatments. The soil lots were maintained at field capacity of soil moisture and soil was sampled at intervals of 1, 2, 4, 7 and 10 weeks and NH_4^+-N and NO_3^--N were estimated.

There were total nine treatments *viz.*

T_1	Urea (control)
T_2	Urea + 1_1, 15% of applied urea
T_3	Urea + 1_1, 30% of applied urea
T_4	Urea + 1_2, 15% of applied urea
T_5	Urea + 1_2, 30% of applied urea
T_6	Urea + 1_3, 15% of applied urea
T_7	Urea + 1_3, 30% of applied urea
T_8	Urea + 1_4, 15% of applied urea
T_9	Urea + 1_4, 30% of applied urea

Where

I_1 = Isolates from neem cake
I_2 = Isolates from sal cake
I_3 = Isolates from kusaum cake
I_4 = Isolates from undi cake

Available nitrogen was determined by extraction with 2 M KCI solution (1:10 soil ::2M KCl). The NH^+- N, the distillation was continued after the addition of Devarda' alloy (Bremner and Keeny, 1996).

RESULTS AND DISCUSSION

The nitrification of applied urea was estimated in terms of ammoniacal nitrogen and nitrate nitrogen (Table 1 and 2). The estimates (Table 1) show that ammoniacal nitrogen and nitrate nitrogen were 30.80 and 23.80 ppm, respectively after on week of incubation in control. The values were significantly increased with the application of isolates from both the levels, except at 15% isolates for *undi* seed cake. After two weeks of incubation (Table 1) in the treatment of isolates form *neem* seed cake, the concentration of ammoniacal nitrogen was at par with that for one week incubation and the concentration of nitrate nitrogen was accordingly less due to *neem* seed cake isolates as compared to other three isolates. The level of nitrate nitrogen was marginally higher at 30% as compared to 15% level of isolates from *sal*, *kusam* and *undi*.

The data on the concentration of ammoniacal nitrogen and nitrate nitrogen after four weeks of incubation (Table -1) reveal that there was substantial rate of nitrification when no isolate was added. The application of the isolates showed a significant capacity to inhibit the ammoniacal nitrogen to be nitrified into nitrate nitrogen. Isolate from *neem* seed cake was more effective over the other. The higher levels of the isolates was more effective in inhibiting the nitrification.

Seven weeks after inoculation (Table 2), it was observed that in control the level of ammoniacal nitrogen drastically reduced to 11.20 ppm whereas, nitrate nitrogen increased to 64.40 ppm. The concentration of ammoniacal nitrogen dropped done due to iolates from *sal, kusum and undi* seed cakes almost to the level of control, but the values remained still higher 916.80 and 20.50 ppm) due to isolates from *neem* seed cake at 15 an 30%, respectively (Table 2). The application of isolates form *neem* seed cake resulted in 37.80 and 32.20 ppm of nitrate nitrogen at 15 and 30% levels, respectively. The values were observed to be significantly lower than due to other isolates after seven weeks of nucleation. The data (Table 2) show that concentration of ammonical nitrogen was significantly lowered to an average value of 10.30 ppm at 10 weeks as against 36.61 ppm at one week of inoculation. The level of nitrate nitrogen were recorded to be lowest due to from *neem* seed cake in both the level after ten weeks of incubation.

The results showed that 4.5 mg urea-N per 100 soil was variably transformed to ammonical nitrogen and nitrate nitrogen with the addition of organic isolates from four different non-edible oil seed cakes as compared to control which received urea only. With the increase in the incubation period the concentration of ammonical nitrogen decreased while that of nitrate nitrogen increesed, but the rate being faster in control pots. After four weeks of incubation the levels of ammonical nitrogen and nitrate nitrogen were found to be almost at par due to treatments of isolates from *sal, kusum* and *undi* cakes, whereas, neem cake isolates was still more effective in inhibiting the process of nitrification and thus maintained a higher level of ammonical nitrogen than nitrate nitrogen. Both at seven and ten weeks of incubation the level of nitrate nitrogen was found to be much higher as compared to ammonical nitrogen in all the treatments. Thus, it was evident that though the isolates from non-edible cakes were effective in inhibiting the process of nitrification but the effect due to *neem* seed cake was much higher as compared to other cakes. The inhibiting effect could be observed upto 7th week of incubation for *neem* seed cake as against up to 4th week incubation due to *sal, kusum* and undi cake isolates. The higher level of the iolates were relatively more effective. Sahrawat and Parmar (1975) also reported that alcohol extract of *neem* seed 30% of the extract (NH_4^+- N basis) was effective upto 75 days period. The results are also in

Table 1. Concentration (ppm) of ammonical nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) in the soil after 1,2 and 4 weeks of incubation with organic isolates

Treatments*	One week after incubation		Two weeks after incubation		Four weeks after incubation	
	NH_4^+-N	NO_3^+-N	NH_4^+-N	NO_3^+-N	NH_4^+-N	NO_3^+-N
Control	30.80	23.80	25.20	32.20	18.20	42.00
Neem cake isolates 15%	37.33	15.40	37.80	16.80	33.60	25.20
Neem cake isolates 30%	45.50	11.20	46.20	13.90	37.80	21.01
Sal cake isolates 15%	33.60	16.80	30.80	19.60	26.62	29.40
Sal cake isolates 30%	38.09	14.01	39.20	22.40	34.37	30.80
Kusum cake isolates 15%	33.60	16.80	29.40	19.60	28.20	29.40
Kusum cake isolates 30%	39.20	15.40	36.40	21.01	35.01	33.60
Undi cake isolates 15%	31.50	18.20	28.01	21.21	27.50	32.20
Undi cake isolates 30%	39.90	14.01	35.03	23.80	32.40	34.90
Mean	36.61	16.18	34.22	21.16	30.41	30.94
C.D. at 5%	1.04	0.60	1.08	0.64	0.83	0.91

* 15 and 30% of oil cake isolates refere to their quantity as per cent of applied urea.

Table 1. Concentration (ppm) of ammonical nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) in the after 1,2 and 4 weeks of incubation with organic isolates

Treatments*	Seven weeks after incubation		Ten weeks after incubation	
	NH_4^+-N	NO_3^--N	NH_4^+-N	NO_3^--N
Control	11.20	64.40	7.01	88.21
Neem cake isolates 15%	16.80	37.80	9.80	71.40
Neem cake isolates 30%	20.50	32.20	14.25	67.0
Sal cake isolates 15%	14.03	47.60	8.40	79.80
Sal cake isolates 30%	18.20	43.40	12.60	75.60
Kusum cake isolates 15%	13.12	44.80	9.80	81.20
Kusum cake isolates 30%	16.80	41.90	11.20	74.20
Undi cake isolates 15%	12.60	46.21	8.20	83.90
Undi cake isolates 30%	15.43	39.20	10.93	77.01
Mean	15.43	44.16	10.30	77.12
C.D. at 5%	0.41	1.17	0.32	2.38

* 15 and 30% of oil cake isolates refere to their quantity as per cent of applied urea.

close conformity with those of Prasad *et al.* (1986) who reported that non-edible oil seed cakes like *neem, karanj, mahua* and *undi* retarted the conversion of ammonical nitrogen to nitrate nitrogen and accumulation of ammonical nitrogen upto 45 days from application of ammonical nitrogen. This inhibition of nitrification process due to these non-edible oil seed cakes could be due to presence of bitter and odoriferous substances (Singh and Gulati 1968). While, Yadav and Shrivastav (1987) explained that the low nitrification rate due to neem cake extracts was because of lipid associates like nimbin and nimbidin in extracts which inhibited the growth of nitrosamines and nitroabactor, the nitrifying bacteria that are responsible for the process of nitrification.

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YIELD ATTRIBUTES, YIELD AND QUALITY OF MUSTARD (*BRASSICA JUNCEA)* AS INFLUENCED BY PHOSPHORUS AND ZINC NUTRITION

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ABSTRACT

An experiment to study the effect of phosphorus and zinc on yield attributes, yield and quality of mustard (*B. juncea)* was conducted during 1999-2000 a the Agronomy form of S.K.N. College of Agrculture, Jobner. The results indicated that application of all the levels of phosphorus and zinc progressively increased Number of siliquae per plant, test weight, seed stover yield, oil content, protein content and oil yield of mustard. But increase in number of siliquae per plant, seed yield stover and oil yield wee found to be significant up to 40 kg P_2O_5 h^{-1} and 5 kg Zn ha^{-1}.

Key words : Mustard, phosphorus, zinc, yield attributes, yield and quality.

In Rajasthan mustard occupies an important crop among all oil seed crops with 28.12 lakhs hectare area and production 26.22 lakhs (Anonymous, 1997-98). Its productivity (726 kg ha^{-1}) in the state in much lower than its releasable yield potential, which is 2200-2400 kg ha-1 (Anonymous, 1997-98). The major constraints for limiting production of mustard yield is poor fertility status of soil, particularly nitrogen, phosphorus and zinc. Keeping in view the inadequate and scanty information of phosphorus and zinc nutrition of mustard crop particularly in light textured soils, the present investigation was carried out to evaluate the effect of phosphorus and zinc on yield attributes, yield and quality of mustard in loamy sand soil.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 1999-2000 at Agronomy farm of S.K.N. College of agriculture, Jobner. The treatment comprising four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four levels of zinc (0, 2.5, 5.0 and 7.5 kg Zn ha^{-1}) were tested in randomized block design with dour replications. Some important physicochemical characteristics of soil are : coarse sand 21.5%, fine sand 54.20%, silt 16.15%, clay 8.15%, pH 8.3, EC 1.3 dSm^{-1}, CEC 5.51 Cmol (p+) kg^{-1} organic carbon 0.22%, the available nitrogen phosphorus, potash and zinc 126.3 Kg N ha^{-1}, 17.2 kg P ha^{-1} 149.26 Kg K_2O ha^{-1}, and 0.44 mg Kg^{-1} Zn

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ha^{-1} respectively. The mustard variety Bio-902 was sown on 3rd November 1999 in *rabi* season. The phosphorus and zinc were applied as per treatment through DAP and $ZnSO_4$ respectively. The nitrogen was applied in two equal splits through DAPand urea at the time of sowing and first irrigation.

RESULTS AND DISCUSSION

Effect of phosphorus

Results indicated (Table 1) that application of phosphorus upto 40 kg P_2O_5 ha^{-1} gave significant increase in number of siliquae per plant. The maximum number of siliquae per plant (330.98) was observed under P_3 (60 Kg P_2O_5 ha^{-1}) which was significantly higher over P_0 (0 Kg P_2O_5 ha^{-1}) and P_1 (20 P_2O_5 ha^{-1}) levels but at par with P_2 (40 Kg P_2O_5 ha^{-1}). This could be attributed to over all improvement in crop growth. The favorable effect of phosphorus fertilization on yield attributes might be probably due to the fact that phosphorus is well known for its role as "energy currency" and play a key in energy transformation and various metabolic processes.

The increase in test weight of seed by application of phosphorus up to 60 kg P_2O_5 ha^{-1}. This might be an account of better and translocation of nutrients specially phosphorus resulting into formation of bold seed by increasing the size and weight of seeds. Similar findings were also reported by Tyagi and Rana (1992).

Application of phosphorus @ 40 kg P_2O_5 ha^{-1} brought significant increase in seed and stover yield (Table 1). The significantly higher seed yield (18.20 $q.ha^{-1}$) and stover yield (40.06 $a.ha^{-1}$) obtained under treatment P_3 (60 kg P_2O_5 ha^{-1}) and stover yield (40.06 $q.ha^{-1}$) obtained under treatment P_3 (60 kg P_2O_5 ha^{-1}) which was significantly higher over P_0 (control) and P_1 (20 kg P_2O_5 ha^{-1}) levels but at par with P_2 (40 kg P_2O_5 ha^{-1}) level. Significant increase in seed and stover yield to be account of beneficial effect of phosphorus on growth and yield attributes of crop. Similar results also reported by Tomar *et al.,* (1997).

Application of phosphorus marginally increased the oil content and protein content in seed while significant increase in oil yield (Table 1). It is revealed from the data oil yield significantly increased by application of phosphorus up to 40 kg P_2O_5 ha^{-1}. The maximum oil yield of 786-kg ha^{-1} was recorded under treatment P_3 (60 kg P_2O_5 ha^{-1}) leve but at par with P_2 (40 kg P2O5 ha^{-1}). This might be ascribed to fact that oil and protein content is largely determined by genetic factors where as increased in oil yield of mustard as a result of phosphorus application appears to be largely due to significant increased in seed yield. These results are in conformity with Arthmawar *et al.,* (1996).

Effect of Zinc

Application of Zinc up to 5.0 kg Zn ha^{-1} significant increased the number of siliquare per plant (table 1.) The level Zn_3 (7.5 kg Zn ha^{-1}) recorded maximum ha^{-1} but at par with Zn_2 (5.0 Kg Zn ha^{-1}). The increase in siliquae per plant might be attributed to the role of Zinc in biosynthesis of IAA (Indole Acetic Acid), which results in better flowering, fruiting and to provide better nutritional environment in the root zone.

The increase in test weight by application of zinc might be an account of better uptake and translocation of nutrient, however, increase in test weight was found to be non-significant.

Significant increase in seed and stover yield (Table 1) with increasing levels of applied zinc up to 5.0 kg ha^{-1}. Which was significantly superior over control and 2.5 kg ha^{-1} but at par with treatment Zn$_3$ (7.5 kg ha^{-1}). Significant increase in seed and stover yield due to zinc application which might be attributed to increased number of siliquae per plant, number of seeds per siliquae, siliquae length and test weight. The findings corroborate of Khurana et al.,(1998).

Application of zinc in general increased the oil and protein content in seed while significant increase was observed in case of oil yield up to 5.0 kg Zn ha^{-1}. The maximum protein (16.25%) and oil content (37.98%) was recorded under treatment Zn3 (7.5 kg ha^{-1}) and minimum with control 15.06% and 36.05% respectively. Incresing dose of zinc up to 5.0 kg Zn ha^{-1} significantly increased the oil yield. The maximum oil yield of 708 kg ha^{-1} was obtained under treatment Zn$_3$ (7.5 kg Zn h^{-1}). Which was significantly superior than Zn$_0$ (control) and Zn$_1$ (2.5 kg ha^{-1}) levels but was statistically at par with Zn$_2$ (5.0 kg Zn ha^{-1}) level. Zinc functions in plants largely as a metal activators and enzymes like cysteine, desulphydrase, dihydropeptides, glycylglycine dioepidase etc. (Tisdale et al., 1985). Thus addition of zinc might have activated the enzymes responsible for the production of oil and protein. Krishna and Singh (1992) also reported beneficial effect of zinc application.

Table 1. Effect of phosphorus and zinc on yield attributes, yield and quality of mustard

Treatment	Yield attributes		Yield		Quality		
	No.of siliquae/ plant	Test weright (g)	Seed yield (q.ha^{-1})	Stover yield (q.ha^{-1})	Protein content (%)	Oil content (%)	Oil Yield (q.ha^{-1})
Phosphorus							
P$_0$ (control)	267.81	4.405	16.28	35.61	15.31	36.67	5.98
P$_1$ (20 kg P$_2$O$_5$ha^{-1})	288.42	4.520	17.10	37.44	15.59	36.97	6.33
P$_2$ (40 kg P$_2$O$_5$ha^{-1})	319.36	4.560	18.06	39.79	15.98	37.36	6.75
P$_3$ (60 kg P$_2$O$_5$ha^{-1})	330.98	4.590	18.20	40.06	16.00	37.63	6.87
SEM±	6.998	0.067	0.23	0.49	0.446	0.74	0.115
C.D. at 5%	20.0	N.S.	0.68	1.39	N.S.	N.S.	0.33
Zinc							
Zn$_0$ (control)	267.59	4.428	15.65	36.10	15.06	36.05	5.65
Zn$_1$ (2.5 kg Zn ha^{-1})	288.95	4.498	17.22	37.79	15.50	37.00	6.37
Zn$_2$ (5.0 kg Zn ha^{-1})	319.02	4.561	18.15	39.41	16.06	37.60	6.83
Zn$_3$ (7.5 kg Zn ha^{-1})	331.02	4.591	18.22	39.60	16.25	37.98	7.08
SEM±	6.998	0.067	0.23	0.49	0.446	0.74	0.115
C.D. at 5%	20.0	N.S.	0.68	1.39	N.S.	N.S.	0.33

Significant increased in oil yield with zinc application up to 5.0 kg ha^{-1} which might be due to increased seed yield of mustard. Similar results also reported by Upadhayay and Singh (1995).

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LONG TERM EFFECT OF CHEMICAL FERTILIZERS ON RICE-WHEAT PRODUCTIVITY AND FERTILITY OF AN INCEPTISOL

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ABSTRACT

A long-term field experiment was conducted during 1981-82 to 1995-96 on an Inceptisol to evaluate the effect of fertilizer use on crop productivity and soil fertility in rice-wheat cropping system. Application of nitrogen @ 120 kg/ha and phosphorus @ 80 kg/ha to each crop significantly increased the grain yield of rice and wheat. There was a build up of organic carbon available P in the soil with NPK fertilization whereas these nutrients declined in the unfertilized plots.

Key words : Long term, fertilizers, grain yield, rice wheat cropping system.

Rice - wheat double cropping is most widely adopted cropping system in the subtroical zone of Jammu Division of J & K State. Continuous cropping with cereals-cereals need balanced use of fertilizer nutrients for susceptibility of this system and nutrients dynamics in long term (Singh *et al.* 1998). The long term experiments provide information on the impact of continuous fertilizer use on the fertility and productivity of the soil. These are also expected to forewarn about the new nutrients deficiencies that may crop in near future. The present paper is an attempt in this direction.

MATERIALS AND METHODS

A long term field experiment was started in 1981 at Regional Agricultural Research Station, R.S. Pura on an Inceptisol with rice-wheat under All India Coordinated Research Project to study the effect of graded levels of N,P and K on rice-wheat productivity and sustainability. The experimental soil was clay loam in texture, pH 7.1, O.C. 0.52% and available N, P and K as 385, 15.5, and 140 kg/ha, respectively. There were 19 treatment combinations consisting of four levels of N (0, 40, 80 and 120 kg/ha), three levels of P_2O_5 (0, 40 and 80 kg/ha) and two levels of K_2O (0 and 40 kg/ha) along with one control. All the eighteen combinations of NPK levels were arranged in a factorial partially confounded design with one control of NPK plot (no fertilizer) in each of the three blocks of each replication. Thus there were 21 plots in each replication. The same treatments were applied to each crop. The rice (PC-19) and wheat (HD-2285) were raised during *kharif* and *rabi* season, respectively. The N, P and

K were applied through urea, single super phosphate and muriate of potash, respectively. The grain yield of both the crops was recorded every year and data was pooled. Soil samples were also collected from each plot at the *rabi* season during 1995-96 and analysed for available N, P, K and organic carbon contents by standard methods (Jackson, 1973).

RESULTS AND DISCUSSION

Grain yield

The grain yields of both the crops viz. rice and wheat increased significantly with increase in N levels up to 120 kg/ha during all the years of experimentation (Table 1). The response of N was higher at lower levels of its application. However, the magnitude of response was higher during initial years (1981-82 to 1986-87) and it decreased gradually in the later years (1987-88 to 1995-96). The continuous reduction in the grain yield of rice and wheat from 1987-88 onwards may be due to deficiency of secondary and micro-nutrients as native reserves of primary, secondary and micro-nutrients as native reserves of primary, secondary and micro-nutrients could have exhausted during long term of continuous cropping which resulted in decreased yield of both the crops. Similar findings have been reported by Bhatnagar *et al* (1994). The application of P @ 80 kg/ha gave significantly higher yield of rice and wheat over control and P_{40} treatment in all the years except initial three years (1981-82 to 1983-84). The higher yield might be due to sufficient availability of P during initial three years of experimentation. It was further observed that the magnitude of response to lower levels of P application over higher levels was more and increased over the years. This may be due to increased available P status of soil at higher levels of phosphorus. Grain yield of rice did not enhance significantly due to potassium application dueing initial six years indicating sufficient K reserves in soils but responded significantly from 1987-89 onwards whereas response of wheat to K application was observed was observed from 1981-84. A significant response to K application during the later years of experimentation might be due to continuous removal of K from soil which left a negative balance of k in the soil and thus decreased grain yield of both the crops. These findings corroborate the observations of Hegdc and Katyal (1998).

Soil fertility

The organic carbon content increased in all the fertilized plots as compared to the initial status (Table 2). The magnitude if increase was more in case of P than N application whereas lowest value of organic carbon content was recorded with K application. The increase might be due to better growth and development of roots resulting in more organic residues in the soil. These findings are in line with those as reported by Lal and Mathur (1989). Available soil N content increased with the increase in N levels. This increase could be due to increased biomass of leftover organic residues in the soil due to application of more N. These findings confirm the observations of Nambiar *et al* (1992). The available soil P increased with increase in P application whereas a slight reduction was recorded with increasing levels of N and P. This could be due to the beneficial effect of N on P

Table 1. Grain yield of rice and wheat (q/ha) under different levels of N, P and K

Treatments	Rice					Wheat				
	1981-83	1984-86	1987-89	1990-92	1993-95	1981-82 1983-84	1984-85 1986-87	1987-88 1989-90	1990-91 1992-93	1993-94 1995-96
Control	18.82	17.50	16.70	14.52	12.80	11.50	11.00	10.00	9.20	8.15
N_1	31.79	37.56	34.29	32.19	29.35	22.90	25.01	22.17	20.79	18.04
N_2	38.35	42.39	40.83	38.09	35.69	28.10	31.04	28.04	24.62	21.98
N_3	42.35	46.33	43.96	40.71	38.33	32.52	34.27	31.94	28.74	26.25
C.D. at 5%	3.58	2.82	2.54	2.15	2.26	3.50	2.80	3.14	3.10	3.62
P_0	33.80	37.92	34.35	32.07	29.83	23.71	24.97	21.70	17.89	15.07
P_1	37.15	41.90	40.88	37.76	35.22	27.62	31.11	28.09	25.28	22.64
P_2	39.85	45.00	43.85	41.15	38.30	31.20	34.24	32.45	30.98	28.40
C.D. at 5%	3.28	3.10	2.85	2.15	3.02	3.75	3.05	2.85	3.60	3.18
K_0	37.56	41.43	38.75	35.75	33.50	27.71	29.14	26.29	23.27	20.36
K_1	37.43	42.79	40.64	38.24	35.42	27.97	31.08	28.54	26.17	23.70
C.D. at 5%	2.15	2.62	1.85	2.52	1.65	1.85	1.55	2.26	2.84	3.10

Table 2. Soil fertility as influenced by long term chemical fertilizewr application

Treatment	Organic carbon (%)	Available N (Kg/ha)	Available P (kg/ha)	Available K (kg/ha)
N (kg/ha)				
Control	0.35	190	11.5	110
40	0.43	265	14.5	138
80	0.45	290	14.2	130
120	0.46	310	13.5	125
P_2O_5 (Kg/ha)				
0	0.40	286	15.1	132
40	0.46	280	17.2	125
80	0.48	270	18.5	122
K_2O (kg/ha)				
0	0.42	266	16.3	130
40	0.43	262	16.0	147
Initial status	0.42	385	15.5	140

and vice-versa which increased the uptake of both the nutrients resulting in decrease of available P content in the soil. There was general decline in available K due to NPK application but the magnitude of reduction was lower with N and K application that may be due to imbalance use of primary nutrients. The reduction may be due to higher removal of K as compared to its addition. Moreover, the decline in available K status of soil might be due to higher removal of K as compared to its addition. Moreover, the decline in available K status of soil might be due to its comparatively lower rate of application. Similar observations have been reported (Hegde and Katyal, 1998).

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CONTAMINATION OF GROUND WATER WITH ARSENIC AS A RESULT OF TUBEWELL IRRIGATION IN WEST BENGAL-A STUDY ON AWARENESS AND PERCEPTION OF FARMERS

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A study was conducted in West Bengal to find out the awareness and perception of farmers about contamination of ground water with arsenic as a result of over exploitation through tubewell irrigation. A very low level of awareness was noticed among majority (51.50%) of farmers about contamination of ground water with arsenic not know to the majority (54.38%) of farmers whereas, a large number of farmers were found to have good awareness about the health hazards caused by drinking of arsenic contaminated water.

Key words *:* Arsenic, groundwater, awareness, West Bengal.

Presence of arsenic in concentration above the maximum permissible limit (< 50 mg/L) i groundwater from the alluvial aquifers has been reported from several parts of the world including West Bengal (Bhattacharya *et al.*, 1996). The problem of arsenic contamination in groundwater in the vast tracts of alluvial aquifers in bengal Belta Pains is a subject of global concern and know to have affected a population of about 38 million in West Bengal (ACIC, 1998). During the last to decades, need of water for domestic as well as irrigation purposes prompted development of ground water resource through tubewells. Such overdraft of ground water could be envisaged as one of the key factors responsible for the spreading of arsenic epidemic in this part of world. Consumption of groundwater with high arsenic content over a prolonged period of time has manifested in adverse health effects among the population such as arsenical dermatosis, hyperkeratosis and several other symptoms of arsenicasois (Goriat *et al.* 1984; Chakraborty *et al.*, 1987; Guha Marumder *et al,* 1988; Das *et al.*, 1996). The rural and semi-urban areas are affected to greater extent because of groundwater is used to a major extent as a source of drinking water. In India, arsenic contamination in ground water was the cause of the disease. Keeping the above facts in the present study was conducted with the following objectives-

1. To study the awareness of the farmers about arsenic and its presence in the ground water.
2. To ascertain the perception of farmers about the reasons for arsenic contamination.
3. To find out the awareness among farmers about the health hazards caused by

consumption of arsenic contaminated water.

MATERIALS AND METHODS

The study was undertaken in the state of West Bengal as many other studies showed that ground water in eight out of seventeen districts of West Bengal as many others studies showed that ground water in eight out of seventeen districts of West Bengal contained arsenic leading to the worst cases of arsenic contamination in the world. According to the state government, about 4.5 million people area exposed to the problem. Two districts namely Burdwan and Nadia had been selected randomly from the 8 districts. Having selected the districts, two blocks, one from each district namely Barddhaman from district of Burdwan and Santiput from the district of Nadia were selected keeping in view the extent of contamination and number of tuberwells. A total of 80 households (40 from each block) using tubewell as the only source of irrigation was selected as main samples. Besides the main samples of 80 respondents, 40 farmers with absolutely rainfed land and 40 farmers with alternative source of irrigation, other than tubewell have been randomly selected for the study.

RESULTS AND DISCUSSION

Awarenes about arsenic and its presence in groundwater

To find out the awarenes about arsenic and its presence in the groundwater responses were taken on a predetermined schedule which reveals their awareness. After they were divided in three groups, viz, high medium and low level of awareness. The results are presented in the Table 1.

Among the tubewell owners (TO) in the Burdwan district it was found that most of them (42.5%) have medium level awareness about the fact where as 32.50 per cent of them were highly aware and about one fourth of them had very low awareness about arsenic contamination in ground water. Only 15 percent of the rainfed farmers (RF) were partially were and 85 per cent of them had very less awareness of the fact. Among the farmers with alternative source of irrigation (FOS), majority (65.0%) was found to have low awareness about presence of arsenic in the groundwater. In Nadia district majority of TO (42.5%) had medium level awareness and majority of RF (70.0%) and FOS (50.0%) had very less knowledge about arsenic contamination. Only 37 % percent TO, 5 percent RF and 15 percent were completely aware about the district together it was found the 45.0 percent were completely aware about arsenic and its presence in the ground water.

To substantiate this result we can make lack of extension campaign as one of the major factor responsible. According to government official lot of steps are taken to provide the villagers arsenic free being because it is very difficult to check over exploitation of ground water through tubewells and it is not done the contamination well go on.

Perception of farmers about the reason of arsenic contamination

To find out what are the reason farmers perceived about contamination of groundwater with arsenic they were asked to mark one of the three option i.e., only tubewell, others except to including tubewell and don't know, as the study was concentrated on tubewell. The result is presented in Table 2.

It is evident from the data that only 25 per cent of TO in Burdwan district made tubewell as sole responsible for the fact whereas 37.50 percent of them do not know the reason: Most of the RF (90.0%) did not know the reason as the opinion is same for FOS because 80.0 per cent of FOS did not know the reason. Overall in the Burdwan district it was seen most of the farmers (61.25%)were not aware about the reason. In Nadia district also majority (35.0%) of TO found that there are other reason except tubewell for contamination of arsenic in groundwater. In case of RF and FOS it was seen that most of then do not know the reason. After combining all the farmers together it was discovered that about 54 percent of farmers do not know the reason where as only about 18 percent seen only tubewellas responsible.

While discussing with farmers lot of other reasons including tubewell has come out. According to them extensive use of pesticide for HYV crops is one of the reason of pollution of ground water. Some of them also told that indiscriminate use of fertilizers, neglecting the appropriate doses may be one of the reason for poisoning their drinking water. They also revealed that they were only told to avoid drinking water from some of the tubewells and advised to use some filters but never told about the reason and mechanism to get rid of this evil.

Table 1. Awareness of farmers about arsenic and it's presence in grounder water

Awareness	Burdwan				Nadia				Combined			
	TO (N=40)	RF (N=20)	FOS (N=20)	Total (N=80)	TO (N=40)	RF (N=20)	FOS (N-20)	Total (N=80)	TO (N=80)	RF (N=40)	FOS (N=40)	Total (N=160)
High	11 (27.50)	0 (0.00)	2 (10.00)	13 (16.25)	13 (32.50)	1 (5.00)	2 (10.00)	16 (20.00)	24 (30.00)	1 (2.50)	4 (10.00)	29 (18.13)
Medium	16 (40.00)	2 (10.00)	3 (15.00)	21 (26.25)	15 (37.50)	5 (25.00)	6 (30.00)	26 (32.50)	31 (38.75)	7 (17.50)	9 (22.50)	47 (29.38)
Low	13 (32.50)	18 (90.00)	15 (75.00)	46 (57.50)	12 (30.00)	14 (70.00)	12 (60.00)	38 (47.50)	25 (31.25)	32 (80.00)	27 (67.50)	84 (52.50)

Figures in the Parentheis indicate percentages.
TO = Tubewell owner RF=Rainfed Farmers FOS-Farmers using alternative source of irrigation except tubewell

Table 2. Perception of farmers about reasons of arsenic contamination in ground water

Awareness	Burdwan				Nadia				Combined			
	TO (N=40)	RF (N=20)	FOS (N=20)	Total (N=80)	TO (N=40)	RF (N=20)	FOS (N-20)	Total (N=80)	TO (N=80)	RF (N=40)	FOS (N=40)	Total (N=160)
Only	10	1	2	13	14	1	2	17	24	2	4	30
Tubewell	(25.00)	(5.00)	(10.00)	(16.25)	(35.00)	(5.00)	(10.00)	(21.25)	(30.00)	(5.00)	(10.00)	(18.75)
Others	15	1	2	18	16	4	5	15	31	5	7	43
	(37.50)	(5.00)	(10.00)	(22.50)	(40.00)	(20.00)	(25.00)	(31.25)	(38.75)	(12.50)	(17.50)	(26.88)
Not Known	15	18	16	49	10	15	13	38	25	33	29	87
	(37.50)	(90.00)	(80.00)	(61.25)	(25.00)	(75.00)	(65.00)	(47.50)	(31.25)	(82.50)	(72.50)	(54.38)

Figures in the Parentheis indicate percentages.
TO - Tubewell owner, RF - Rainfed Farmers FOS - Farmers using alternative source of irrigation except tubewell

Table 3. Awareness of farmers about healt hazards due to presence of arsenic in ground water

Awareness	Burdwan				Nadia				Combined			
	TO (N=40)	RF (N=20)	FOS (N=20)	Total (N=80)	TO (N=40)	RF (N=20)	FOS (N-20)	Total (N=80)	TO (N=80)	RF (N=40)	FOS (N=40)	Total (N=160)
High	25	2	7	3	32	4	5	41	57	6	12	75
	(62.50)	(10.00)	(35.00)	(42.50)	(80.00)	(20.00)	(25.00)	(51.25)	(71.25)	(15.00)	(30.00)	(46.88)
	10	5	8	23	6	7	12	25	16	12	20	48
	(25.00)	(25.00)	(40.00)	(28.75)	(15.00)	(35.00)	(60.00)	(31.25)	(20.00)	(30.00)	(50.00)	(30.00)
Low	5	13	5	23	2	9	3	14	7	22	8	37
	(12.50)	(65.00)	(25.00)	(28.75)	(5.00)	(45.00)	(15.00)	(17.50)	(8.75)	(55.00)	(20.00)	(23.13)

Figures in the Parenthesis indicate percentges
TO-Tubewell owner, RF -Rainfed Farmers FOS-Farmers using alternative source of irrigation except tubewell

Awareness among the farmers about health hazards due to consumption of arseniferous ground water

After discussion with the experts and reviews it was found that arsenic is poisonous in doses significantly larger than 65 mg/litre and a single larger dose of repeated small doses of arsenic can cause poisoning. Very larger dose of arsenic can cause death also. Arsenic is absorbed from the gastrointestinal tract into the blood stream. So, it was felt necessary by the researcher to find out the awareness level among farmers about this health hazards. The data related to this are presented in the Table 3.

The data in the table reveals that most of the TO (40.0%) in Burdwan district had medium level of awareness about the health problem created by arsenic. Whereas only 27.5 percent of them were high aware and 32.5 percent had low awareness about the fact. Most of the RF (90.0%) and Fos (7.5%) had very low awareness about the situation. Overall in Burdwan district awareness level was very low in case of health hazards due to arsenic in ground water. In Nadia district also the result was more or less same. Most of the TO (37.5%) had medium level of awareness and majority of RF (70.0%) had very less awareness about the different diseases caused arsenic consumption through prolonged period. Overall, taking all farmers together it was observed that majority (52.5%) of farmers do not have good knowledge about this serious situation.

While discussing with farmers it was found that even if they know that their tubewell water contained arsenic they do not have options but to use it. Most of them use conventional filter to get rid of this because they told that recommended filters are costly and it was not possible to install it. According to government officials, they have abandoned some tubewells and identified some zones where further installation of tubewell is discouraged, because installation of tubewell in such areas may increase contamination of drinking water with arsenic.

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RESPONSE OF PLANT GROWTH REGULATORS AND MICRONUTRIENT MIXTURES ON FRUIT SIZE, COLOUR AND YIELD OF TOMATO *(LYCOPERSICON ESCULENTUM, MILL)*

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ABSTRACT

The experiment was laid out in two Factor Factorial Randomized Block design with 15 treatments combinations and was replicated thrice. The growth regulator (IAA and NAA) were applied at 25 and 50 DAT @ 25 ppm and 75 ppm respectively. The two micronutrients mixtures (Multiplex and Humar) were applied @ 2500 and 2000 ppm at 25 and 50 DAT, respectively on the tomato cultivar *Krishna* (F_1-hybrid). The largest size of fruits (6.67 cm. diameter) was observed with 75 ppm NAA alongwith multiplex (P_4M_1) at maturity stage of tomato. The maximum yield of tomato (63:61 tonne/ha) was observed with treatment combinations P_4M_1 as compared to control. Attractive colour of ripe tomato fruits i.e. Cherry (Phantom, 2L-12) was recorded with P_4M_1 as compared to control (P_0M_0). The maximum dry matter (2.65%) and ash content (1%) were significantly registered with 75 ppm NAA alongwith Humar (P_2M_2).

Key words : Plant growth regulators, micronutrients - multiplex, tomato.

Tomato is one of the most important vegetable crop, because of its nutritive value and medicinal properties, it is being cultivated in India on commercial as well as domestic purpose in all stage. The plant growth regulators (PGR) alongwith micronutrient mixture has profound effect on the productivity of crop and improving the quality of crop as well as provide resistance against physiological disorder.

MATERIALS AND METHODS

A trial conducted in the experimental field of Department of Agricultural Chemistry, Allahabad Agricultural Institute, Allahabad, during two successive year of *rabi* season (1997-1999). The experiment was laid out in two Factor Factorial Randomized Block Design with 15 treatment combinations and replicated thrice. Plant growth regulators IAA and NAA were applied on plant @ 25 and 75 ppm respectively at 25 and 50 DAT. The two micronutrient mixtures namely Multiplex (Karnatka Agro chemicals, Banglore) and Humaur

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were applied @ 2500 ppm and 2000 ppm respectively. The tomato cultivar *Krishna*, F_1-hybrid was used for experimental trial.

The fruit size were measured in diameter, of randomly selected five fruits of each treatment with he help of Vernier Callipers at the maturity stage. Dry weight and ash content of tomato fruits were calculated by standard methods. The intensity of colour of ripped fruits were recorded and compared with the help of block *"Dictionary of colour"* by Maerz and Paul (1930). The randomly selected plants of each plot at maturity stage were uprooted alongwith ripe fruits, washed, dried and weighed to determine the fresh weight as yield.

RESULTS AND DISCUSSION

The results are shown in Table 1 and briefly discussed below:

Fruit size

It was significant ($P<5\%$) increased with 75 ppm NAA alongwith Multiplex (P_4M_1) over control during both years. The largest fruits size i.e. 6.76 cm, (35.20% increased) was recorded, in the treatment of growth promoters and micronutrient mixtures multiplied may be due to the direct enhancement of growth as promoted by NAA at higher levels.

The key role probably played by micronutrients, which increased the fruit size. Similar findings have been reported by others including Dellaceca and Mancini (1989).

Dry matter and ash content

Higher values of dry matter of plants and ash content were recorded with 75 ppm NAA alongwith Humaur (P_4M_2). The growth regulators are known to promote better uptake and Utilization of nutrients alongwith water, which may in turn increased the utilization of nutrients present in soil. This may be reason why the plant receiving both growth regulators and micronutrients recorded higher value of dry matter and ash content. Our results are in conformity with the findings of Ranganathan and Perumal (1995).

Colour intensity

The intensity of colour in tomato fruits largely depends upon the development of lycopene, balanced nutrition and length of sunshine. The best colour intensity was observed with the treatments of 75 ppm NAA alongwith Multiplex (P_4M_1). This may be due to the fact that the plant receiving growth regulators alongwith micronutrient had resulted in healthy growth. Use of PGR promoted bright colour as reported by, Matanaga (1997) and Singha *et al.*(1986).

Yield

The yield of tomato was significantly ($P<5\%$) enhanced (36%) due to PGR and micronutrient mixtures. The maximum yield of 61.66 tonne/ha and 63.61 tonne/ha first year and second year's respectively was registered with the 75 ppm NAA alongwith multiplex (P_4M_1) as compared to control, 45 tonne/ha. This may be due to the fact that the PGR alongwith micronutrients mixtures have promoted lateral branching and growth in the plants besides increasing root-

Table 1. Response of plant growth regulators and micronutrient mixtures on fruit size, colour and yield of tomato

Treatments combination	Symbol	Fruits Size (cm)		Dry Weight (%)		Ash Content (%)		Yield (tonnes/ha)		Colour Intensity
		I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	
Control	P_0M_0	5.00	5.00	2.00	2.08	0.34	0.30	45.27	45.46	Toboggan
Multipex	P_0M_1	5.13	5.10	2.20	2.22	0.38	0.36	49.45	50.00	Mikado
Humaur	P_0M_2	5.48	5.47	2.22	2.26	0.40	0.38	50.83	51.12	Mikado
25 ppm IAA	P_1M_0	5.70	5.60	2.20	2.29	0.45	0.45	47.49	48.34	Flame Flarentine
25 pp, IAA + Multiplex	P_1M_1	5.58	5.62	2.26	2.30	0.49	0.48	50.83	50.83	Midnight Sun
25 ppm IAA + Humaur	P_1M_2	5.19	5.17	2.29	2.25	0.56	0.55	55.56	56.12	Bitter Sweet
75 ppm IAA	P_2M_0	5.90	5.87	2.25	2.27	0.57	0.62	50.55	51.67	Flamingo
75 ppm IAA + Multiplex	P_2M_1	600	5.95	2.32	2.34	0.66	0.65	55.00	55.56	Sungod
75 ppm IAA + Humaur	P_2M_2	5.75	5.70	2.36	2.40	0.70	0.68	60.55	62.49	MANDARIN-R
25 ppm NAA	P_3M_0	5.76	5.75	2.38	2.43	0.56	0.58	55.00	56.12	Scarlet vermilion P
25 ppm NAA + Multiplex	P_3M_1	6.21	6.20	2.46	2.51	0.74	0.72	58.34	60.00	PIMENTO (chinese vermilion P (2L-11)
25 ppm NAA + Humaur	P_3M_2	6.10	6.07	2.50	2.56	0.80	0.75	59.44	61.12	Fire cracker
75 ppm NAA	P_4M_0	6.32	6.29	2.43	2.47	0.85	0.85	56.66	57.78	Pirate
75 ppm NAA + Multiplex	P_4M_1	6.76	6.36	2.62	2.65	0.95	0.93	61.66	63.61	CHERY (Phantom)
75 ppm NAA + Humaur	P_4M_2	6.25	6.22	2.65	2.70	1.00	0.98	57.78	59.45	Fire-red
STATISTICAL ANALYSIS										
Micronutrient	SEm	0.23	0.029	0.018	0.012	0.008	0.007	0.192	0.130	
Auxins	SEm	0.030	0.026	0.023	0.015	0.011	0.009	0.192	0.168	
Interaction	Sem	0.053	0.046	NS	0.027	0.019	0.016	0.333	0.291	
Micronutrient	C.D. (P 5%)	0.048	0.042	0.370	0.024	0.017	0.015	0.149	0.267	
Auxins	C.D. (P 5%)	0.062	0.054	0.048	0.032	0.023	0.019	0.349	0.344	
Interaction	C.D. (P 5%)	0.109	0.942	NS	0.055	0.040	0.034	0.683	0.597	

SEm : Standard Error of mean. C.D. = Critical Difference, NS + Non Significatn

I Years (1997 - 98). II years (1998-99).

ing. The higher yield was primarily due to more number of branches with bigger fruit size and fruit set. PGR has increased the yield of tomato fruits as confirmed by similar findings have been reported by Swaroop *et al.* (1998) obtained higher yield with 50 ppm and 100 ppm, NAA due to increase in the number of fruits/plant. Shittu and Adeleke (1999) also reported that 500 ppm GA_3, promoted fruit set, higher number of fruits and yield. According to Jaiswal *et al;* (1997) who reported that multiplex has increased marketable fruit yield by 25. 1% as compared to the control. Micronutrients increased to tomato fruits yield as reported by Elabeen and Methlly (1982), Maharana *et al;* (1990), Bose and Tripathi (1996). Thus, the present findings are in conformity with the results reported by above mentioned scientist.

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EFFECT OF LEVELS OF NITROGEN ON WHEAT AS INFLUENCED BY DATE OF SOWING

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ABSTRACT

Field experiments were conducted at Indian Agricultural Research Institute, New Delhi during 1992-1993 and 1993-1994 to study the effect of sowing date on the response of wheat to nitrogen. Results indicated that delay in sowing from November 16 to December 16 resulted in a significant reduction in plant height, number of tillers and earhead/m in row length, earhead length, number of grains/earhead and test weight, which led to a significant reduction in grain and straw yield of wheat. Delay in sowing from November 30 to December 16 reduced the grain yield by 8 per cent, whereas further delay in sowing from December 16 to December 31 reduced the grain yield by 19 per cent.

Nitrogen application significantly increased growth and yield attributing characters which led to a significant increase in grain and straw yield of wheat particularly in late sown crop. At 120 kg N/ha delay in sowing from November 30 to December 16 did not cause a reduction in grain yield. Late sown crop required more nitrogen; economic optimum dose of nitrogen for December sown crop was about 100 kg N/ha against 80 kg N/ha for November sown crop. The response to nitrogen at economic optimum dose was higher in late sown wheat; about 20 kg grain/kg N in December sown crop against 17 kg grain/kg N in November sown crop. Both agronomic efficiency and apparent recovery of fertilizer nitrogen were also higher in late sown wheat. The adverse effect of delayed sowing could be mitigated to some extent by application of higher dose of nitrogen.

Key words : Wheat, sowing dates, nitrogen, yield attributes, yields, agronomic efficiency, apparent recovery.

In intensive cropping system, sowing of wheat (*Triticum aestivum* L. emend, Fioro & Paol) generally gets delayed as it is sown after a short duration catch crop of potato (*Solanum tubersum* L.) or Indian rapeseed (*Brassica compestris* L. var. toria, Duth. & Full) or after a long duration rice (*Oriza sativa* L.) or sugarcane (*Saccharum officinarum* L.) ratoon. Under such situations yield of wheat declines. However such reduction in the productivity can be mitigated to some extent if optimum fertilizer doses are applied to wheat. Data on optimum dose of nitrogen for wheat sown at different dates are meagre. Hence the present study was carried out to study the effect of nitrogen on the growth and yield of wheat sown at different dates.

MATERIALS AND METHODS

Field experiment was conducted at Indian Agricultural Research Institute, New Delhi during *rabi* 1992-93 and 1993-94. The experiment was laid out in a split plot design with three dates of sowing (30 November, 16 December and 31 December) in main plots and four levels of N (0, 40, 80 and 120 kg N/ha) in sub plots. There were three replications.

The soil of the experimental field was sandy loam with 0.59% organic C (Walkley and Black, 1934), 90.4 mg/kg soil NaOH – $KMno_4$ hydrolisable N (Subbiah and Asija, 1956), 9.9 mg/kg soil 0.5 N $NaHCO_3$ extractable P and 117 mg/kg soil 1 N ammonium acetate extractable K (Prasad, 1967).

Wheat cultivar 'HD 2285' was sown with a tractor drawn seed drill at a row spacing of 23 cm. The crop received basal application of 17 kg P as single super phosphate and 35 kg K/ha as muriate of potash at sowing. Nitrogen as urea as per treatment was applied in two splits, half at sowing and rest half at 35 days after sowing. The crop was harvested in the third week of April in both the years.

Plant height, tillers/m row length, ears/m row length, ear length, grains/earhead and test weight were recorded at harvest of the crop. Grain yield was calculated at 14% moisture, whereas the straw yield was recorded on oven dry basis. Since the trend of the data on growth and yield attributing characters as well as grain and straw yields were similar in both the years, the data were pooled over two years.

RESULTS AND DISCUSSION

The crop sown on 30 November produced significantly taller plants and more tillers/m row length than the crop sown on 16 and 31 December; latter dates of sowing did not differ significantly (Table 1).

Plant height and tillers/m row length increased with increasing rate of nitrogen upto 120 kg N/ha; however the differences

Table 1. Effect of nitrogen levels on growth characters of wheat as influenced by date of sowing (data pooled over two years)

Nitrogen level (kg N/ha)	Plant height (cm) Dates of sowing				Tillers/m row length (Nos) Dates of sowing			
	30 Nov	16 Dec	31 Dec	Mean	30 Nov	16 Dec	31 Dec	Mean
0	84.1	77.1	74.4	78.5	94.0	82.0	79.0	85.0
40	90.2	83.3	83.4	85.6	111.8	88.0	89.9	96.6
80	91.5	85.2	85.2	87.3	107.4	104.9	97.2	103.2
120	90.4	87.7	90.1	83.3	106.01	101.5	110.3	106.2
Mean	89.0	83.3	83.3	-	105.0	94.1	94.1	-
C.D. at 5% Date (D)	:	2.95				9.89		
N	:	1.77				5.58		
D x N	:	3.06				14.85		

between 40 and 80 and 80 and 120 kg N/ha were not significant in respect of tillers/m row length.

Interaction between sowing dates and nitrogen rates was significant in case of both plant height and tillers/m row length and it indicated that plant height increased with increasing rate of N upto 40 kg N/ha in crop sown on 30 November and upto 120 kg N/ha in the crop sown on 16 and 31 December. Similar trend was observed in case of tillers/m row length except that the tillers/m row length in the crop sown on 16 December increased with increasing rate of nitrogen application upto 80 kg N/ha. These results indicated that late sown crop required more nitrogen for attaining similar plant height and producing similar number of tillers/m row length than early sown crop.

Yield attributes

The crop sown on 30 November produced significantly more ears/m row length but similar ear length, grains/earhead and test weight when compared with 16 December sown crop, which in turn produced similar ears/m row length and significantly higher ear length, grains/earhead and test weight than 31 December sown crop (Table 2). The first 15 days delay in sowing affected only ear/m row length, whereas second 15 days delay in sowing affected ear length, grains/earhead and test weight of wheat.

There was an increase in number of ears/m row length, ear length and grains/ear and decrease in test weight of wheat with increasing rate of nitrogen upto 120 kg N/ha, however, the difference between 80 and 120 kg N/ha was not significant in respect of all the above mentioned characters.

The interaction between sowing dates and nitrogen rates indicated that the delay in sowing from 30 November to 16 December significantly reduced the ears/m row length when 0 or 40 kg N/ha was applied and grains/earhead and test weight only when no nitrogen was applied. When rate of nitrogen application was more than 40 kg N/ha, these characters were not affected by delay in sowing from 30 November to 16 December. Similarly delay in sowing from 16 December to 31 December significantly reduced the ear length only when no nitrogen was applied to wheat. This indicated that adverse effect of delay in sowing on yield attributing characters can be mitigated by application of nitrogen. However this was not true in case of test weight of wheat where the adverse effect of delay in sowing was further aggravated by higher rate of nitrogen.

Grain and straw yield

Delay in sowing from 30 November to 31 December decreased both grain and straw yield (Table 3). The first 15 days delay in sowing reduced the grain yield by 8 per cent and the second 15 days delay by 19 per cent. The reduction in straw yield was 23 per cent due to first 15 days delay and 16 per cent due to second 15 delay. Higher grain and straw yield in early sowing as compared to late sowing was due to favourable temperature during early vegetative growth and grain filling period, which resulted in the improvement in growth and yield attributing characters like tillers and ears/m row length, ear length, grains/earhead and test weight. The adverse effect of delay in sowing on grain yield of wheat has also been reported by Hundal and

Table 2. Effect of nitrogen levels on yield attributes of wheat as influenced by dates of sowing (data pooled over two years)

Nitrogen levels	Dates of Sowing			
(kg N/ha)	30 Nov	16 Dec	31 Dec	Mean
		Ear/m row length (Nos.)		
0	82.5	72.8	68.5	74.6
40	103.4	82.7	84.7	90.3
80	99.2	95.8	93.3	96.1
120	99.7	102.5	102.9	101.6
Mean	96.2	88.4	87.3	-
C.D. at 5% Date (D)		7.93		
N		6.98		
D x N		12.09		
		Ear length (cm)		
0	7.8	8.3	7.8	8.0
60	9.1	9.1	9.0	9.1
80	9.5	9.4	9.1	9.3
120	10.2	9.7	9.6	9.8
Mean	9.1	9.1	8.9	-
C.D. at 5% Date (D)		0.21		
N		0.31		
D x N		0.54		
		Grains/earhead (Nos.)		
0	32.8	29.6	29.9	30.8
40	37.7	36.1	34.1	35.9
80	39.5	37.7	34.6	37.3
120	39.2	40.8	36.9	39.0
Mean	37.3	36.0	33.9	-
C.D. at 5% Date (D)		1.59		
N		1.69		
D x N		2.93		
Test weight (g)				
0	45.1	44.6	44.6	44.8
40	44.2	43.8	44.0	44.0
80	44.3	43.9	42.1	43.4
Mean	44.1	43.8	42.6	-
C.D. at 5% Date (D)		0.63		
N		0.82		
D x N		1.43		

Table 3. Effect of nitrogen levels on grain and straw yields (t/ha) of wheat as influenced by date of sowing (data pooled over two years)

Nitrogen level (kg N/ha)	Grain yield Dates of sowing				Straw yield Dates of sowing			
	30 Nov	16 Dec	31 Dec	Mean	30 Nov	16 Dec	31 Dec	Mean
0	3.75	2.90	2.15	2.93	6.15	4.28	3.08	4.50
60	4.73	4.28	3.54	4.18	7.53	5.91	5.30	6.25
80	5.13	4.77	3.98	4.62	8.61	6.88	5.54	7.01
120	4.87	5.05	4.12	4.68	8.77	6.73	5.96	7.15
Mean	4.62	4.25	3.45	-	7.76	5.95	4.97	-
C.D. at 5% Date (D)			0.425			0.517		
N			0.181			0.347		
D x N			0.314			0.601		

Sandhu, 1990; Tiwari and Singh, 1993.

Both grain and straw yield increased significantly with the increase in nitrogen application upto 80 kg/ha. The first 40 kg N/ha increased the grain yield over control by 43 per cent, whereas the second 40 kg N/ha increased grain yield further by 10 per cent. Higher dry matter production with increased levels of N application resulted in better expression of growth and yield attributing characters. These ultimately resulted in significant increase in grain and straw yield.

The interaction effect between sowing dates and nitrogen rates was significant in case of grain yield of wheat and it indicated that delay in sowing from 30 November to 16 December resulted in a significant reduction in grain yield when rate of nitrogen application ranged from 0 to 80 kg N/ha, whereas at 120 kg N/ha the delay in sowing did not cause a reduction in yield. These results showed that higher application can mitigate the reduction in yield due to delay in sowing.

The relationship between rates of nitrogen and grain yield of wheat was studied by using regression equations (Table 4). The response was quadratic in all dates of sowing. The economic optimum dose of N was the highest (105.8 kg N/ha) for 16 December sown crop and the lowest (79.8 kg N/ha) for 30 November sown crop, whereas the yield at economic optimum dose was the highest in 30 November sown crop and the lowest in 31 December sown crop. However the response at economic optimum dose was the highest in 31 December sown crop followed by 16 December and the lowest in 30 November sown crop indicating that nitrogen application was more profitable in late sown crop.

Agronomic efficiency of nitrogen

Agronomic efficiency of the crop sown on 16 and 31 December was similar but significantly higher than that of the crop sown on 30 November (Table 5). Higher agronomic efficiency in late sown crop as compared to early sown crop was due to higher response to N in late sown crop as compared to early sown crop.

Agronomic efficiency decreased significantly with each successive increase in nitrogen rate upto 120 kg N/ha. Low agronomic efficiency of higher rate of N was due to poor response to higher rates of N. Similar trend was observed by Joseph (1991).

Interaction effect between sowing dates and nitrogen rates was found significant and it showed that at 40 and 120 kg N/ha, the crop sown on 16 and 31 December gave significantly higher agronomic efficiency than 30 November sown crop, whereas at 80 kg N/ha there was no significant difference in agronomic efficiency of the crop sown at different dates.

Apparent recovery

The highest apparent recovery of

Table 4. Response of wheat to nitrogen as influenced by dates of sowing (based on pooled data)

	Date of sowing Items		
	30 Nov	16 Dec	31 Dec
Response equation	$Y=3.743+0.03265x-0.00019x^2$	$Y=2.934+0.3785x-0.00017x^2$	$Y=2.182+0.03936x-0.00019x^2$
Economic optimum dose (kg N/ha)	79.8	105.8	96.0
Yield at economic optimum dose (t/ha)	5.1	5.0	4.6
Response at economic optimum dose (kg grain/kg N)	17.2	19.8	20.5

Table 5. Effect of nitrogen levels on agronomic efficiency and apparent recovery of nitrogen as affected by dates of sowing (data pooled over two years)

Nitrogen level (kg N/ha)	Agronomic efficiency (kg grain/kg N)				Apparent recovery (%)			
	30 Nov	16 Dec	31 Dec	Mean	30 Nov	16 Dec	31 Dec	Mean
40	24.6	34.5	34.8	31.3	64.4	74.8	71.8	70.3
80	17.2	23.3	22.9	21.1	49.1	55.9	50.0	51.7
120	9.4	18.0	16.4	14.6	34.6	47.7	40.1	40.8
Mean	17.1	25.2	24.7	-	49.4	59.5	54.0	-
C.D. at 5% Date (D) :		5.09				10.65		
N :		3.48				7.30		
D x N :		6.03				12.71		

applied nitrogen was in 16 December sown crop and the lowest was in 15 November sown crop (Table 5). Each successive increase of 40 kg N/ha resulted in a significant decrease in apparent N recovery due to poor response of wheat to higher rate of N than lower dose.

The interaction effect between dates of sowing and rates of nitrogen was found significant and its showed that at 40 and 80 kg N/ha apparent recovery was similar in crops sown at different dates, whereas at 120 kg N/ha the apparent recovery of nitrogen was significantly higher in 16 December sown crop than in 30 November sown crop. This indicates that late sown crop was more efficient in utilizing higher dose of nitrogen.

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RESIDUAL EFFECT OF WEED AND NUTRIENT MANAGEMENT APPLIED TO MAIZE (ZEA MAYS L.) ON SUCCEEDING WHEAT (*TRITICUM AESTIVUM* L.) CROP

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ABSTRACT

The study of residual effect of weed and nutrient management in wheat (*Triticum aestivum* (L.) after maize revealed that amongst various treatments of weed and nutrient management applied in maize, only the treatments involving FYM application in maize [100% NP through FYM 10t/ha and fertilizer and 100% NP through fertilizer + FYM 10t/ha had significant residual effect in enhancing ear bearing tillers/m row length, grains/ear, grain, straw and biological yield as well as uptake of N and P by grain, straw and total uptake by the crop compared to remaining treatments of nutrient management i.e. 100, 125 and 150% NP through fertilizer. Neither weed nor nutrient management treatments affected both weed intensity and their dry weight in succeeding wheat crop.

Key words *:* Weed and nutrient management, maize, wheat, residual effect.

Maize - wheat cropping system is most prevalent in sub humid southern plain and arawali hills of Rajasthan where farmers have a feeling that the use of herbicides to control weeds in maize has some residual effect on wheat and therefore critical of using herbicides for weed control in maize. Nutrient losses caused by weeds in maize may be compensated through weed and nutrient management. Farmers in the area apply nutrients to the succeeding crop without taking into consideration their residual effect. While in recent years, the emphasis has been shifted from individual crop to cropping system as a whole. Since, the response in component of the cropping system are influenced by preceding crops and inputs applied in them. Organic manures, phosphatic fertilizers as well as herbicides have carry over effect on the succeeding crops (Mali *et al.* 1993. Makaya, 1998 and Saghir and Chowdhory, 1967). In want of sufficient work on residual effect of weed and nutrient management, it is imperative to study the weed and nutrient management use in maize for their residual effect on wheat.

MATERIALS AND METHODS

A field experiment was conducted consecutively during *kharif* and *rabi* seasons of 1997-98 and 1998-99 at Instructional Farm, Rajasthan College of Agriculture,

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Udaipur. Thirty treatment combinations consisting of six weed management [weedy check (W_0), intercultivation at 20 and 35 DAS (W_1), atrazine at 0.5 kg/ha as pre-emergence (W_2), glyphosate at 0.5 kg/ha 21 DAS (W_3), atrazine at 0.5 kg/ha as pre-emergence+intercultivation at 35 DAS (W_4) and atrazine at 0.5 g/ha as pre-emergence followed by glyphosate at 0.5 kg/ha 21 DAS (W_5)] in main plot and five nutrient management treatments [100% NP though fertilizer (F_1) 12% NP through fertilizer (F2), 150% NP through fertilizer (F_3), 100% NP through FYM 10 t/ha and fertilizer (F_4) and 100% NP through fertilizer + FYM 10 t/ha (F_5)] in sub plots were tested in split plot design with four replications. The soil of the experimental site was clay loam in texture and alkaline in reaction. The soil was medium in available nitrogen and phosphorus and high in potassium. 90 kg N and 35 kg P_2O_5/ha through urea and single superphosphate, respectively were used as recommended dose of fertilizer in maize. After harvesting of maize crop, the field was irrigated at right soil moisture content. The plots were demarcated precisely on the same points (5.0 m x 3.6 m) as they were done for maize crop keeping the net plot size in wheat as 4.0 m x 2.7 m. Wheat variety 'Raj 3077' was sown at 22.5 cm row spacing on 23 and 13 November and harvested on 9 and 6 April in the respective seasons. The crop was raised on residual fertility with uniform dose of only 70% of recommended nitrogen (70 kg N/ha). Half of the nitrogen was applied at sowing time and remaining half was applied at first irrigation. No intercultural operations were done during the crop seasons of wheat. Weed intensity in wheat was recorded at 40 DAS by counting the weeds presented in 0.25 m^2 area from each net plot which was randomly ascertained by using 0.5 m X 0.5 m quadrat. In order to make data more valid, data of weed intensity were transformed to Arcsin $\sqrt{\%}$ transformation.

RESULTS AND DISCUSSION

The major weeds of experimental site in wheat were *Chenopodium album* L., *Chenopodium murale* L., *Parthenium hysterophorus* L., *Convolvulus arvensis* L., *Cynodon dactylon* (L.) Pears., *Meliotus indica* (L.) and *Spergula arvensis* L.

Residual effect of weed management

All the weed management practices adopted in preceding maize crop had no significant residual effect on weed intensity and their dry weight. It indicated degradation of atrazine or glyphosate completely or below certain levels which did not influence weeds in succeeding crop longevity, both of them might have degraded before sowing of succeeding wheat (Sharma and Angiras, 1997 and Dekker and Duke, 1995). All the yield attributes, yield as well as uptake of N and P by wheat weed not significantly affected by adopting different weed control practices in preceding crop of maize (Table 1). Atrazine and glyphosate carry no effect on yield of succeeding crop in maize-wheat rotations (Khan and Saghir, 1989; Kumar and Singh, 1991).

Residual effect of nutrient management

Application of various nutrient management treatments to preceding maize crop under sub optimal uniform application of N in wheat has no significant impact on

Table 1. Residual effect of weed and nutrient management on yield attributes and yield of wheat

Treatment	Yield attributes						Yield (q/ha)							
	Ear bearing		Grains/ear		Test weight		Grains		Stover		Biological		Harvest index	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Weed management														
W_0	92.1	86.3	35.9	34.4	41.88	40.32	41.26	37.02	56.94	51.55	98.20	88.57	42.07	41.78
W_1	90.3	87.7	37.1	35.6	42.68	40.82	39.12	36.42	53.65	51.29	92.77	87.71	42.20	41.51
W_2	89.8	88.2	36.8	34.1	42.66	40.57	39.89	36.20	55.64	51.74	95.53	87.94	41.76	41.18
W_3	89.5	85.0	36.1	34.3	42.72	39.82	40.79	35.00	56.65	49.99	97.44	84.99	41.93	41.21
W_4	87.0	89.1	36.8	35.4	42.56	39.95	38.70	35.78	54.09	49.77	92.78	85.25	41.71	42.00
W_5	88.0	86.4	35.5	34.7	42.35	39.29	39.51	36.19	55.53	50.85	95.04	87.04	41.62	41.64
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management														
F_1	85.2	82.6	35.3	33.6	41.65	40.24	38.16	34.06	53.05	48.40	91.21	82.46	41.79	41.33
F_2	86.6	83.8	35.1	34.0	42.15	39.78	38.42	34.76	53.74	49.46	92.16	84.22	41.74	41.29
F_3	88.0	84.9	34.6	34.2	42.0	39.29	38.54	35.17	54.04	49.86	92.16	84.22	41.74	41.29
F_4	93.4	91.5	38.2	35.9	43.08	40.51	41.79	37.99	57.92	53.00	99.70	90.99	41.94	41.73
F_5	94.0	92.6	38.5	36.0	43.09	40.8	42.48	38.53	58.34	53.35	100.82	91.87	42.17	41.96
C.D. 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Residual effect of weed and nutrient management on nutrient uptake by wheat (kg/ha)

Treatment	Nitrogen						Phosphorus					
	Grain		Stover		Total		Grain		Stover		Total	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Weed management												
W_0	75.30	68.23	26.62	25.26	101.92	93.43	15.67	13.82	8.30	7.38	23.97	21.20
W_1	70.52	67.09	24.96	24.21	95.48	1.3	14.89	13.58	7.71	7.45	22.59	21.03
W_2	72.46	66.10	25.66	24.29	98.12	90.83	14.87	13.66	7.78	7.42	22.65	21.07
W_3	73.92	64.14	26.48	24.11	100.42	88.24	15.13	13.08	8.05	7.27	23.18	20.35
W_4	70.42	65.63	24.88	23.42	95.30	89.06	14.46	13.29	7.68	6.98	22.13	20.27
W_5	72.58	66.56	25.86	23.72	98.43	90.3	14.73	13.79	7.77	7.50	22.49	21.29
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management												
F_1	68.32	61.51	24.16	22.49	92.47	84	14.05	12.59	7.40	6.89	21.44	19.48
F_2	69.06	62.89	24.56	23.03	93.63	85.95	14.32	12.91	7.51	7.07	21.83	19.97
F_3	69.95	63.99	24.77	23.51	94.42	87.5	14.47	13.14	7.67	7.13	22.13	20.27
F_4	77.23	70.99	27.43	25.79	104.66	96.76	15.78	14.39	8.44	7.67	24.21	22.05
F_5	78.42	72.08	27.80	26.02	106.21	98.1	16.17	14.65	8.39	7.91	24.56	22.57
C.D. at 5%	4.697	3.763	1.720	1.355	5.396	4.054	10.33	0.714	0.573	0.454	1.244	0.833

weed intensity and their dry weight in wheat crop. However, treatments involving FYM application in maize i.e. F_4 and F_5 treatments resulted in significant increase in ear bearing tillers/m row and grains ear but test weight remained unaffected by residual FYM. Grain straw and biological yield and uptake of N and P by grain, straw and total uptake of these nutrients by succeeding crop during both the years increased significantly with F_4 and F_5 treatments with non significant difference between them for the said parameter (Table 2). This could be ascribed to increased availability of nutrient in the soil under the residual effect of FYM at the end of maize harvest as FYM acts as nutrient reservoir and release major and minor nutrients slowly. Besides this, FYM also solubilize native as well as fertilizer P through production of organic acids. Thus, it might have balanced N:P ratio for wheat crop by supplying P in addition to that contained in FYM and compensated P removal by maize. Results so obtained are in close agreement with Suri *et al.* (1997). Significant increase in nutrient uptake under the residual influence of FYM might be due to significant increase in the yield and it is well established fact that the uptake of nutrient is mainly the function of yield. Results are in close agreement with the findings of Patidar (2000) tested under sorghum - wheat cropping system.

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PHOTOSYNTHETIC AND YIELD RESPONSE OF WHEAT VARIETIES UNDER IRRIGATED AND RAINFED CONDITIONS IN HILLS

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ABSTRACT

A field experiment with six wheat *varieties viz.* Sonalika, Kalyan Sona, VL 616, Opal, Bezostaya, Blue Boy was taken up to understand the photosynthetic basis of yield in wheat under irrigated and rainfed conditions, Rates of photosynthesis, canopy photosynthesis, transpiration and leaf temperature depression exhibited the significant reduction under rainfed condition. Blue Boy had the highest photosynthesis rate under irrigated condition whereas under rainfed condition, Sonalika and VL 616 maintained higher photosynthesis rate and grain yield. Moreover, VL 616 and Sonalika exhibited higher drought tolerance efficiency, which indicated that VL 616 and Sonalika had the mechanism(s) for better functioning of physiological processes like photosynthesis under rainfed condition. Further, significant positive association of relative water content (r=0.570*) and leaf temperature depression (0.754**) with drought tolerance efficiency in turn suggested their importance for screening the wheat genotypes for drought tolerance.

Key words : Photosynthesis, transpiration, relative water content, grain yield, rainfed wheat.

In Uttaranchal hills, about 90 per cent land area of wheat is under rainfed conditions. As the rainfall distribution is erratic and inadequate in rainfed areas, therefore, productivity of wheat is poor due to exposure to drought spell in hills. Wheat genotypes differ, in terms of grain yield and their susceptibility to drought occurring at different stages of growth (Sairam *et al.*, 1990, Saxena *et al.*, 1996). Dryland cultivars possess some adaptive characteristics which influences their agronomic performance in water limited environment. Variability in physiological traits can serve as criteria for improving wheat adaptation to drought. Therefore, an attempt has been made to study photosynthesis, yield and their associated traits among wheat varieties under irrigated and rainfed conditions.

MATERIALS AND METHODS

A field experiment with six wheat (*Triticum aestivum* L.) varieties belong to diverse groups *viz.* Sonalika (early spring), Kalyan Sona (late spring), VL 616 (intermediate), Opal (mild winter), Bezostaya (mild winter), Blue Boy (strong winter type) was conducted in factorial randomized block design with three replications under irrigated and rainfed conditions during the *rabi* 1998-99. Total rainfall during course of investigation was 346.70mm. There was no rainfall during November and December. However, in month of October, January, February, March, April and May it was observed 64.5, 65.6, 30.8, 109.6 and 75.1mm respectively. In the set of wheat varieties grown under irrigated condition, in addition to rainfall, three irrigations were provided for maintaining the sufficient moisture. A recommended package of practices was followed to raise the healthy crop under both conditions. Different physiological parameters were recorded at gain filling stage. Leaf photosynthetic rate (Pn) (μ mole/m^2/s), transiration rate (TR) (m mole/m^2/s), stomatal conductance (SC) (m mole/m^2/s) and leaf temperature (°C) were measured on flag leaves using portable photosynthesis system (model CIRAS- I, U.K.). Canopy photosynthesis (CPn) and leaf temperature depression (LTD) were estimated by following the methods as reported earlier (Kumar *et al.*, 2000). Relative water content (RWC%) was measured by following the method described the Weatherley (1970). Drought tolerance efficiency (%) was determind by using the formula suggested by Lewis (1954). Total dry matter, yield and its attributes were recorded at harvest. Data obtained were analysed by adopting standard statistical methods.

RESULTS AND DISCUSSION

The wheat varieties varied considerably in photosynthesis and associated parameters at grain filling stage (Table 1). Relative water content, transpiration rate, stomatal conductance, leaf temperature depression and rates of photosynthesis showed a significant reduction under rainfed condition. Under rainfed condition, Sonalika and VL 616, showed considerably higher relative water content than other varieties. Besides this, Sonalika and VL 616 also maintained higher rates of photosynthesis and canopy photosynthesis under rainfed condition while Blue Boy and Kalyan Sona and higher rates of canopy photosynthesis under irrigated condition. High rates of photosynthesis among wheat varieties Sonalika and VL 616 under rainfed condition, thus appears to be the results of maintenance of turgor in their leaves as indicated by the high relative water content. Similar, results were reported by earlier workers (Upreti and Sirohi, 1985, Sairma *et al.*, 1990, Saxena *et al.*, 1996). Reduction in stomal conduction under rainfed conditions probably took place due to increase in level of ABA because accumulated ABA adversely modulates stomatal behaviour (Jensen *et al.*, 1996). Since, stomatal conductance controls the gaseus exchange, therefore, reduction in stomal conductance under ranged condition also lowered the rates of photosynthesis and transpiration. Moreover, leaf temperature depression depends on the loss was also noted under rainfed condition. Further, drastic reduction in canopy photosynthesis under rainfed condition, was mainly due to reduction in leaf area.

Varietal differences were also noted in terms of yield and drought tolerance efficiency among wheat varieties under both irrigated and rainfed conditions (Table 2). A significant reduction in plant height, total dry matter, test weight and grain yield was

Table 1. Relative water content (RWC %), transpiration rate (TR), stomatal conductance (SC), leaf temperature depression (LTD), photosynthsis rate (Pn) and canopy photosynthesis (CPn) among wheat varieties under irrigated and rainfed conditions

Treatment	Variety	RWC	TR	SC	LTD	Pn	Cpn
Irrigated condition	Sonalika	94.95	8.07	507.00	3.50	14.58	39.60
	K. Sona	92.15	8.90	502.75	3.62	11.57	39.81
	VL616	93.00	8.37	522.15	3.75	13.30	36.62
	Opal	90.91	8.22	577.55	3.61	12.35	29.57
	Bezostaya	90.00	9.55	510.25	3.85	13.26	29.93
	Blue Boy	93.42	8.47	484.00	3.77	14.95	45.29
	Mean	92.41	8.60	517.28	3.68	13.34	36.80
Rainfed condition	Sonalika	94.80	8.04	508.20	2.07	13.73	24.44
	K. Sona	83.15	7.67	439.00	1.15	7.40	10.36
	VL616	93.75	8.10	511.30	2.10	13.75	25.30
	Opal	85.05	7.76	531.75	1.85	12.92	21.05
	Bezostaya	84.98	7.26	460.80	1.13	11.26	17.79
	Blue Boy	89.00	7.03	422.40	1.05	10.45	1.26
	Mean	88.45	7.64	478.91	1.56	11.59	19.03
C.D. at 5%	Treatment (T)	0.12	0.24	16.56	0.04	0.44	0.70
	Variety (V)	0.21	0.42	28.69	0.06	0.76	1.21
	GXV	0.30	0.59	40.57	0.09	1.08	1.71

Table 2. Plant height, total dry matter (TDM), test weight and grain yield of wehat varieties under irrigated and rainfed conditions and their drought tolerance efficiency (DTE)

Treatment	Variety	Plant height (cm)	TDM (q/ha)	Test wt. (q/ha)	Yield (q/ha)	DTE (%)
Irrigated condition	Sonalika	94.61	79.69	46.96	35.75	75.02
	K. Sona	72.80	75.57	43.90	31.97	69.16
VL616	103.50	89.65	49.70	35.05	71.09	
	Opal	98.80	90.14	37.76	36.07	68.61
	Bezostaya	88.21	90.63	41.30	38.95	60.70
	Blue Boy	92.06	92.27	44.15	39.52	62.95
Mean	91.66	86.33	43.96	36.22	67.92	Rainfed
Sonalika	82.26	58.32	45.40	26.82	-	
condition	K. Sona	62.53	50.14	39.96	22.11	-
	VL616	88.93	56.03	46.03	24.92	-
	Opal	90.33	58.89	35.20	24.75	-
	Bezostaya	72.86	55.92	38.53	23.68	-
	Blue Boy	80.06	51.68	38.26	24.88	-
	Mean	79.50	55.16	40.56	24.53	-
C.D. at 5%	Treatment (T)	1.24	0.71	0.36	0.50	-
	Variety (V)	2.44	1.22	0.63	0.68	-
	GXV	3.03	1.73	0.89	1.21	-

noted under rainfed condition. Wheat varieties Blue Boy, Bezostaya, Opal and Kalyan Sona showed higher grain yield under irrigated condition. These varieties exhibited more reduction in grain under rainfed condition, as compared to Sonalika and VL 616. Present results showed that reduction in canopy photosynthesis under rainfed condition was an important cause of reduced crop yield because reduced photosynthetic surface persists even after the stress (drought) is relieved.

The results indicated a differential response of varieties under rainfed and irrigated conditions. Further, wheat varieties Sonalika and VL 616 proved their better tolerance to drought, as they exhibited higher values for drought tolerance efficiency. It appears that an in built system of water economy in the tolerant varieties enable them to maintain vital physiological functions and results higher yield than susceptible varieties under adverse climatic condition.

Furthermore, relative water content (r=0.570*) and leaf temperature depression (r=0.754**) recorded at grain filling stage in wheat varieties under rainfed condition exhibited the significant positive association with drought tolerance efficiency (Fig. 1-2) which suggested that these physiological traits can be used for screening the wheat genotypes for drought tolerance. Relative water content has also been suggested as an important criterion for screening the wheat genotypes for drought tolerance (Ritche *et al.*, 1990) and a relation between canopy minus air temperature and leaf water potential in field grown wheat was noted earlier (Singh and Singh 1984). Moreover,

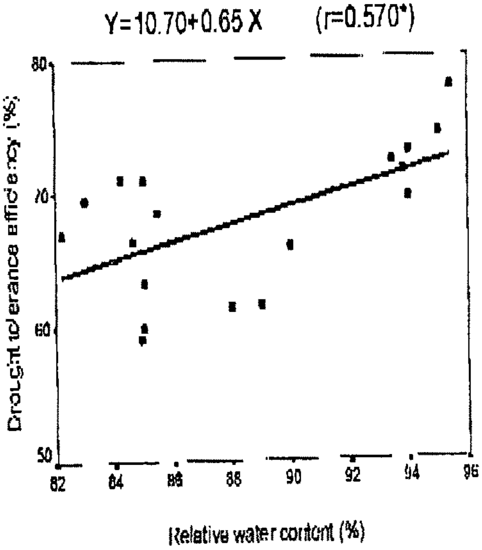

Fig. 1. Assoiciation betweeen relative water content and drought tolerance efficiency among what varieties

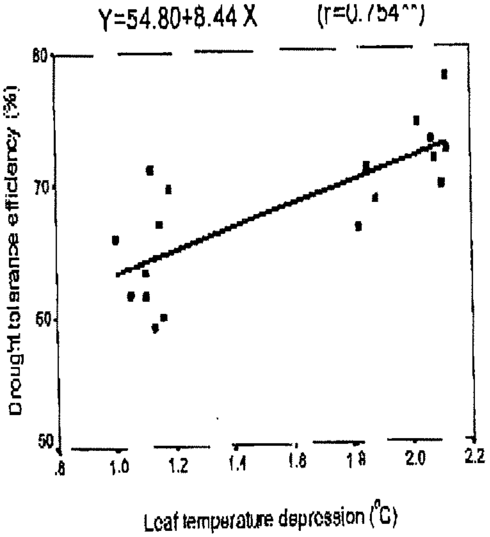

Fig. 2. Relationship between leaf temperature depression and drought tolerance efficiency among wehat varieties

Kumar *et al.*, (2000) reported the significant positive association between leaf temperature depression and grain yield in barnyard millet under rainfed condition. Thus, it is concluded that leaf temperature depression should be further investigated as potential selection criterion for drought tolerance.

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EFFECT OF NON-SYMBIOTIC NITROGEN FIXERS ON THE FORAGE YIELD OF OAT (*AVENA SATIVA* L).

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ABSTRACT

Field investigation conducted during 1992-93, 1993-94 and 1994-95 revealed that, application of biofertilizer viz. Azotobacter @ 250 g/10 kg of seed produced significantly higher green fodder yield and dry matter yield over control. Similarly, the application of nitrogen @ 80 kg/ha produced significantly higher green as well as dry fodder yield of oat during the three years and also in the pooled data. The response to nitrogen was graded and significant.

Key words : Oat, *Azatobactor*, nitrogen, forage.

Oat (*Avena sativa* L.) is a non leguminous green fodder, commonly used in animal feeding in northern region of the country. In recent years, oat is gaining importance in Maharashtra as a *rabi* season forage crop. It is a heavy forage yielder and responsive to irrigation and nitrogen application. Nitrogen fertilizers play an important role in increasing productivity of forage crop. However, increasing cost of chemical fertilizers often restrict their use, hence it becomes imperative to substitute nitrogen by some other cheaper sources which may partially meet crop requirement. Nitrogen economy in crop management can be ensured by use of biofertilizers. The inoculation with non-symbiotic nitrogen fixer like *Azotobactor* increased crop yields from 15 to 30 percent (Anonymous, 1989). Keeping this in view the present study was undertaken to assess the response of oat to nitrogen and non-symbolic nitrogen fixers under agroclimatic conditions of Konkan region.

MATERIALS AND METHODS

The field experiments were conducted at Grass Breeding Station, Palghar, Dist. Thane during *rabi* season of 1992-93, 1993-94 and 1994-95. The experiment was laid out in factorial randomized block design with three replications. Gross plot size was 4.5 m x 3.5 m and net plots size was 4.00 m x 3.00 m. Eight treatment combinations were formulated with two levels of Azotobactor (without and with *Azotobactor*) and four levels of nitrogen (0, 40, 60 and 80 kg/ha). Oat var. 'JHO-822' was sown at 25 cm row spacing using seed rate of 100 kg/ha. Azotobactor @ 250 g/10 kg of seed was applied just before sowing. Full dose of 30 kg P_2O_5 and 20 kg K_2O/ha and half dose of N as per the treatments was applied at the time of sowing and remaining half dose of nitrogen was applied after one month of sowing. The soil of the experimental field was medium black, alkaline in reaction, medium in available nitrogen and available phosphorus and rich in available potash. Crop was sown in first week of December and harvested at 50% flowering stage. Need based protection measures were followed.

RESULTS AND DISCUSSION

Effect of Azotobacter

The differences due to biofertilizer (Azotobacter) application in respect of green fodder yield and dry matter yield of oat were significantly superior over no biofertilizer treatment during all the years as well as in pooled analysis except in the year 1992-93(Table 1). During 1992-93 et al. the dry matter yield differences wee non-significant. This increase in green fodder yield with Azotobacter was attributed to increased vegetative growth of plants.

Shetty *et al.* (1976) also noticed the increase in yield due to Azotobacter inoculation ranging form 12 to 30 percent. Sadhu *et al.* (1991) and Desale *et al* (1999) also reported similar results.

Effect of nitrogen

The increasing levels of nitrogen form 0 to 80 kg/ha progressively increased the green fodder yield and dry matter yield during three years as well as in the pooled analysis.

The response to nitrogen in green fodder yield and dry matter yield was graded and significant. Similar results were reported by Verma and Singh (1986) and Gill *et al.* (1988).

Effect of Interaction

Interaction effects were non -

Table 1. Year wise amd pooled mean data of green fodder yield and dry matter yield (q/ha) of oat as influenced by Azotobacter and levels of nitrogen

Treatments	1992-93		1993-94		1994-95		Pooled mean	
	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield
II. Azotobacter (AB)								
No *Azotobacter*	317.98	48.00	335.24	74.83	342.40	66.96	242.83	62.76
Azotobacter	321.70	49.57	346.22	77.47	360.00	69.13	248.30	64.97
C.D. at 5%	3.24	NS	1.82	1.54	1.91	2.08	0.87	0.58
II. Nitrogen levels (kg/ha)								
N0	180.95	28.70	230.63	58.23	199.30	39.09	156.60	42.06
N40	312.70	50.57	56.28	79.26	369.30	76.11	249.41	67.76
N60	366.13	55.93	370.32	81.58	408.61	76.86	272.35	71.45
N80	419.58	59.93	405.69	85.54	427.58	80.11	303.88	74.20
C.D. at 5%	4.59	3.75	2.58	2.18	2.70	2.94	1.23	0.82

significant.

In nut shell, for green forage and dry fodder from oat, the crop should be fertilized with 80 kg N/ha alongwith Azotobacter inoculation @ 25 g/kg of seed under agroclimatic conditions of Konkan.

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PRODUCTION POTENTIAL OF DIFFERENT INTERCROPPING SYSTEMS IN SUGARCANE UNDER AGROCLIMATIC CONDITIONS OF KONKAN REGION

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ABSTRACT

Field trails to identify the short, suitable and profitable intercrop in sugarcane under agroclimatic conditions of Konkan were conducted during 1990-91, 1991-92 and 1992-93 at Central Experiment station, Wakawali, Dist. Ratnagiri. There years pooled results revealed that intercropping of radish for leafy vegetable in *suru* planted sugarcane gave the maximum gross as well as net returns/ha emerged as the most profitable intercropping system by registering Rs. 11,499/ha as an additional profit as compared to sole crop of sugarcane. This system also recorded the highest B:C ratio of 2.47. The crops namely chilli, cluster bean, cucumber and coriander also found profitable intercrops with Rs. 6446, 4479, 1444 and 800/ha additional net profit respectively than sugarcane alone. Sugarcane + chilli, sugarcane+cucumber and sugarcane+cluster bean also recorded higher B:C ratio than sugarcane alone. Intercropping of maize in sugarcane significantly affected the height, girth and weight of cane. However, brix sucrose and purity percentage as well as commercial cane sugar was not influenced significantly due to different intercropping systems under study. The sole crop sugarcane recorded significantly higher cane yield (128.91 t/ha) over all intercropping systems under study.

Key words : Sugarcane, intercropping system, economics.

Intercropping is one of the sure way of increasing production without much increase in the application of inputs. Intercropping refers to growing of two or more crops simultaneously on the same piece of land. This system gives crop intensification of both time and space. Apart from its advantages like diversification, labour distribution, maintencane of soil fertility, suppression of weeds, two major advantages are higher productivity and greater stability through utilization of solar energy, moisture and nutrients.

Sugarcane requires 4 to 6 weeks for germination and initial growth is also very slow for fist two months. This time required for germination and subsequent initial slow growing period can be made better use of growing short duration intercrop as a bonuos crop. Dagade and Patil (1986), reported that intercropping of vegetables in sugarcane did not affect the yield and quality of sugarcane. Similarly, Razzaque *et al.* (1978) reported that, mustard, potato tomato, lentil, sesame and cabbage had no appreciably bad effect on yield, components and sucrose content of sugarcane. Keeping this view, the present study was planned to identify the best suitable and profitable intercrop in *suru* (seasonal) planted sugarcane under *Knokan* climatic conditions.

MATERIAL AND METHODS

The experiment was conducted at Central Experiment Station, Wakawali for three seasons during 1990-91, 1991-92 and 1992-93 in randomized block design with three replications. The gross and net plot size was 5.40 m x 6.00 m and 3.60 x 5.00 m, respectively. The soil of the experimental plot was lateritic, acidic in reaction (pH 5.94) and sandy clay loam in texture, low in available phosphorus and medium in available potassium and nitrogen content.

The experiment consisted of the following treatment combinations:

T : Sole crop of sugarcane (No intercrop)

T_2: Sugarcane + cowpea ('VCM 8'), dibbling on the shoulder of ridges, 15 cm. apart.

T_3: Sugarcane + maize ('Ganga safed'), dibbling on the shoulders of ridges, 30 cm. apart.

T_4: Sugarcane+watermelon ('Sugarbaby'), dibbling on the shoulder of ridges (one side) 2 m apart.

T_5: Sugarcane +cucumber ('Pune khira'). dibbling on the shoulder of ridges (one side) 2 m apart.

T_6: Sugarcane + chilli ('Konkan kirti'), planted on shoulder of ridges, 45 cm apart.

T_7: Sugarcane + cluster bean ('Pusa navbahar'), dibbling on he shoulder of ridges, 45 cm. apart.

T_8: Sugarcane + radish ('Local'), line sowing on the shoulder of ridges.

T_9: Sugarcane + coriander (Local). Line sowing on the shoulder of ridges.

The sugarcane variety 'Co 7527' was planted in the month of January in respective years and intercrops were sown/planted one week after cane planting. The intercrop was harvested before earthing-up. Sugarcane crop of all the treatments was fertilized with 250 kg N, 125 kg P_2O_5 and 125 kg K_2O/ha. The 10 percent nitrogen and full dose of K_2O and P_2O_5 was applied at the time of planting. Out of remaining dose of nitrogen, 40%, 10% and 40% nitrogen was given at an interval of 6 weeks from each preceding dose. Need based plant protection and weed control measures were followed. One earthing-up was given in the month of June after the commencement of the monsoon rain. No any special fertilizer application was done to the intercrops grown in the sugarcane. Harvesting of the sugarcane crop was done in the first week of February every year. The growth, yield and quality of cane at harvest and yield of intercrop was recorded.

Effect on sugarcane

The sole crop of sugarcane recorded significantly higher height over sugarcane + maize, sugarcane + cucumber and sugarcane + radish intercropping systems (Table 1), whereas it was on par with sugarcane + cowpea, sugarcane + water meln, sugarcane + chilli, sugarcane + clusterbean and sugarcane + coriander intercropping systems.

A regards the girth and weight of cane, it was significantly influenced by different intercropping systems. Both the girth and

Table 1. Data on growth characters, juice quality, cane and sugar yield (Mean of three plant crops)

Treatment	Millable cane population/ ha	Height of millable cane	Girth (cm)	Weight of cane (kg)	Brix (%)	Sucrose %	Purity (%)	Cane yield (t/ha)	CCS (t/ha)
Control sugarcane alone	67099	316.33	10.46	1.98	18.83	16.69	88.63	128.91	14.94
Sugarcane + cowpea	60185	301.55	9.60	1.83	20.23	17.19	84.78	109.84	13.09
Sugarcane + maize	42346	249.67	9.26	1.53	18.84	16.40	86.39	67.58	7.84
Sugarcane + cucumber	63952	296.11	10.19	1.83	19.52	17.23	87.81	116.91	13.85
Sugarcane + chilli	57840	302.66	9.62	1.88	18.35	16.50	89.55	110.88	12.51
Sugarcane + cluster bean	60617	306.00	9.96	1.91	18.14	16.21	87.54	112.26	12.43
Sugarcane + radish	60317	294.56	9.64	1.94	19.54	17.36	88.17	114.83	13.79
Sugarcane + coriander	64011	301.22	9.78	1.89	18.49	17.00	85.95	117.20	13.78
C.D. at 5%	-	16.84	0.94	0.23	NS	NS	NS	10.31	NS

NS : Not significnat

weight per cane was maximum under sole crop of sugarcane, which was significantly higher over the sugarcane + maize intercropping system and on par with remaining intercropping systems. This has clearly indicated that maize has created competition with sugarcane for nutrients, space as well as sunlight, which affected the height, girth and weight of sugarcane adversely.

As far as quality aspects of sugarcane is concerned, the brix, sucrose and purity percentage as well as commercial cane sugar was not influenced significantly due to different intercropping systems under study. Lakshmikantam *et al.* (1971) also reported that, raising of intercrop did not affect sucrose content of sugarcane.

The cane yield of sugarcane was significantly influenced by different intercropping systems. The sole crop of sugarcane produced significantly higher cane yield over all intercropping systems under study. Amongst the different intercropping systems, sugarcane + coriander produced the maximum cane yield, which was significantly higher over sugarcane + maize intercropping and on par with the remaining intercropping systems. The lowest cane yield was observed under sugarcane + maize intercropping system. Suryavanshi _ *et al.* (1986). also reported the adverse effect on cane yield due to intercropping of maize in sugarcane.

Gross returns/ha :

The intercropping of radish in sugarcane gave maximum gross returns of Rs. 64, 530.50/ha, which was high by Rs. 13, 331.70/ha as compared to sole crop of sugarcane (Table 2). Intercropping of chilli,

Table 2. Comparison of input cost, gross income and net income of sole crop of sugarcane and different crop combinations

Particular	Sugarcane alone (control)	Sugarcane + cowpea	Sugarcane +maize	Sugarcane + water melon	Sugarcane + cucumber	Sugarcane + Chili	Sugarcane +cluster bean	Sugarcane +radish	Sugarcane + coriander
Cost of inputs required for main crop of sugarcane	24279.7	24279.7	24279.7	24279.7	24279.7	24279.7	24279.7	24279.7	24279.7
Cost of inputs required for intercrop	-	1313.6	1530.0	974.0	816.3	1545.7	1553.7	1832.3	1277.7
Total input cost of sugarcane + intercrop	24279.7	25593.3	25809.7	25253.7	25096.0	258254	25833.4	26112.0	25557.4
Yield of sugarcane (t/ha)	128.9	109.8	67.6	107.6	116.9	110.9	112.3	114.9	117.3
Yield of intercrop (kg/ha)	-	467.20	1595.60	3770.0	1714.8	1683.3	2472.2	14103.7	1883.3
Gross value of sugarcane	51198.8	42985.3	26438.3	42668.7	46599.9	46237.0	44870.8	45452.7	46491.9
Gorss value of intercrop	-	5693.3	10536.8	7540.7	6859.2	12953.7	12361.1	19077.8	6785.2
Total gross value of sugarcane + intercrop	51198.8	48678.6	36975.1						
Net returns in Rs.									
Additional amount over sole crop	-	-	-	-	1444.0	6446.0	479.0	11499.0	800.0
Benefit : cost ratio	2.11	1.90	1.43	1.99	2.13	2.29	2.22	2.47	2.08

cluster bean, coriander and cucumber in sugarcane also recorded higher gross returns than the sole crop of sugarcane.

Net returns/ha

Sugarcane + radish intercropping system recorded the maximum net returns of Rs. 11, 499.00/ha as an additional profit as compared to sole crop of sugarcane. The intercrops viz. chilli, cluster bean, cucumber and coriander were also found to be suitable intercrops giving Rs. 6446,4479, 1444 and 800/ha additional net profit, respectively as compared to the profit accrued through sugarcane alone.

Benefit : cost ratio

Intercropping of radish for leafy vegetable purpose in *suru* planted sugarcane recorded the highest B : C ratio of 2.47. The sole crop sugarcane recorded the B : C ratio of 2.11. Sugarcane + chilli, sugarcane + cucumber and sugarcane + cluster bean systems also recorded higher B : C ratio than sugarcane alone.

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INCREASE IN CELLULAR CONTENT OF CHITINASE AS RESPONSE TO POWDERY MILDEW INFECTION IN PEA: DETECTION THROUGH ENZYME LINKED IMMUNOSORBANT ASSAY (ELISA)

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ABSTRACT

Changes in cellular content of chitinases has been investigated in twelve powdery mildew resistant and twelve powdery mildew susceptible lines *of* pea through ELISA using antibodies developed against purified chitinase from *Seratia marcescens.* Chitinase activity was recorded in all the lines prior to powdery mildew infection. Powdery mildew infection triggered synthesis of chitinase in all the lines. But the increase was 1.8 times higher in resistant lines as compared to susceptible ones. Pre-infection level of chitinase played no role on post-infection level of chitinase in the lines.

Key words : Chitinase, ELISA, pea.

Plants defend themselves by activity producing different defence molecules including phytoalexins (Stevenson *et al.*, 1997), phenols (Sharma *et al.*, 1996), synthesis of hydroxyproline-rich glycoproteins (Hammerschmidt *et al.*, 1984) and induction of pathogenesis-related (PR) proteins (Bol *et al.*, 1990). Most prominent among the PR proteins are chitinases and β-l, 3-glucanases (Loon *et al.*, 1994). Chitinases and β1, 3- glucanases are reported to be co-induced in response to biotic and abiotic stresses (Mauch *et al.*, 1984). These hydrolytic enzymes inhibit fungal growth by hyphal tip lysis. The two enzymes have synergistic effect in inhibiting the fungal growth (Mauch *et al.*, 1988). Synthesis of chitinases and 13-1, 3-glucanases in response to pathogen infection, has been reported from pea by various authors (Dumas *et al.*, 1994; Chang *et al.*, 1995). Powdery mildew infection leads to induced synthesis of these two enzymes in many systems (Ignatius *et at.*, 1994). However, behaviour of these two enzymes in response lo powdery mildew infection has not been investigated in pea so far. In pea powdery mildew is caused by the fungal pathogen, Erysiphe *pisi* DC ex St-Am.

Enzyme linked immunosorbant assay (ELISA) is a very sensitive technique to detect the presence of specific protein (antigen) in any sample (Clark, 1981). It is being used in different plant systems to detect presence of specific protein in plant cells. In this communication we report use of ELISA to detect changes in cellular content of chitinases with response to powdery mildew disease in pea.

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MATERIALS AND METHODS

Twelve powdery mildew resistant (PMR) and 12 susceptible (PMS) lines were used in the present investigation. All the lines were obtained from Division of Genetics, IARI, New Delhi. Seeds were sown late (December 5) in the field, as late sown crops are prone to the disease. Infector rows of PMS variety, Bonneville were sown around the test lines. Fungal spores from diseased plants were dusted over the test lines as uniformly as possible to create sufficient inoculum load. Leaf samples were collected from all the lines before the onset of the disease (January 10) and after the establishment of disease (March 20) for the study. Polyclonal antibodies against purified chitinases from *Serutia nulrcescens* (M/S Sigma Chemicals, USA) were prepared in New Zealand white rabbits by four intra-muscular injections administered at 10 days interval according to Hurnad and Chantler (1980). On each occasion, 0.5 mg of purified chitinase emulsified with equal volume of Freund's complete adjuvant was injected. The animal was bled 15 days after last injection and antiserum was collected. Direct antigen coated ELISA (DAC-ELISA) was done on polystyrene plates (Corning, New York, USA) using the protocol described by Clark and Bar-Joseph (1984). Crude extract of chitinase prepared from the leaf samples according lo Rakshit *et al.* (1998) was used to load the ELISA plates. Buffer and purified chitinases *S. marcescens* (M/S Sigma Chemicals, USA) served as negative and positive controls, respectively. Antisera and antirabbit irnunoglohulin-Horseraddish peroxidase were used at 1 :500 and 1 :2000 dilutions, respectively. The reactions of ELISA were read at 492 nin 1 h after adding substrate (O-phenylenediaininc dihydrochloride) by using a Dynetech ELISA reader.

RESULTS AND DISCUSSION

Out of the several dilutions of the antiserum tested, 1:500 was found optimum for detection of chitinase extract from leaves (data not shown). ELISA readings of 12 PMR and 12 PMS lines before and at disease establishment is presented in Fig. 1. Pre-infection cellular content of chitinases was recorded in all the lines irrespective of their response to powdery mildew. This background chitinases are synthesized constitutively. After disease was established in the field chitinase level increased in all the lines as revealed by increase in ELISA readings. However, the increase was more conspicuous in PMR lines as compared to PMS ones. In the PMR group the increase

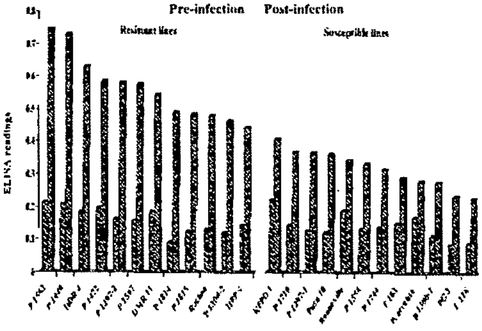

Fig. 1. ELISA readings under pre- and post infection conditions in different genotypes of pea

in readings was on an average 3.54 fold over pre-infection level. The corresponding value in the PMS group was only 2.26 fold. This signifies that disease-induced synthesis of chitinases in the PMR lines was more as against the PMS lines. It is noteworthy that the induced level of chitinase after fungal infection was not correlated with the chitinase level prior to infection. For example, rank of HFP4 among PMR group was eighth in terms of cellular content of chitinases before infection but during post-infection period its rank went down to last among the 12 resistant lines. Similarly, rank of Pusa 10 increased from ninth to fourth among the susceptible lines during the post-infection period. Some PMS lines viz. KFPD 1 and P 1710 showed higher chitinase level during pre-infection stage as against some PMR genotypes viz. P 1814, P 1815, Rachna and P 1300-2. However, none of the PMS lines showed higher chitinase content after disease establishment in the field. This indicates that constitutive synthesis of chitinase plays no role in infection-induced synthesis of the enzyme at least in pea against *E. pisi* infection. Powdery mildew triggers cellular synthesis in all the lines but the induction is more in the resistant group as compared to susceptible lines. This gives a preliminary information that chitinases play a role in powdery mildew resistance in pea. Chitinases are reported to play antifungal role in plant defence process. Along with b-l,3-glucanases, chitinases inhibit fungal growth by hyphal tip lysis (Mauch *et al.*,1988). Both chitinases and β 1,3-glucanases are reported to be located in intercellular as well as vacuolar fluids (Kan *et al.*, 1992; Regalado and Richardo, 1996). It is suggested that extracellular enzymes prevent the extracellular growth of the pathogens while upon entry of pathogen into the cell decoinpartinentalization of vacuolar fluids leads to release of chitinases and 13-1,3-glucanases resulting in prevention of further spread of the pathogens. Ignatius *et al.*, (1994) demonstrated the role of chitinases and β-l, 3-glucanascs against powdery mildew in barley. They reported lower level of chitinases in near-isogenic susceptible lines. Role of chitinases in powdery mildew has been demonstrated in many cases (Kunoh *et al.* 1990).

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REACTION OF SOME RICE GENOTYPES TO BACTERIAL BLIGHT PATHOGEN

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Bacterial blight disease of rice caused by *Xanthomonas oryzae.* pv *oryzae* (Swings *et al.,* 1990) is widespread with varying levels of disease severity in different rice growing regions of the world. This may be possible due to the differences in the genetic makeup of the varieties or the existence of strains in the pathogen. Several workers reported the specialization in pathogen. Therefore, there is a need to screen the rice genotypes against prevalent strains of this pathogen. Thus the present investigation was aimed to screen the rice genotypes and to identify the resistant cultures against "6R" (Thri Murthy *et al.,* 1993) local isolate of bacterial blight pathogen.

During wet season (June-October) of 1995, 40 rice genotypes were tested for their degree of susceptibility against '6R' isolate of Chattisgarh bacterial blight pathogen at maximum tillering stage.

Seedlings were grown on the raised seed bed and 25 days old seedlings were transplanted in a well puddled field. Nitrogen fertilizer was applied in the form of urea at the rate of 140 kg N/ha. The experiment was conducted in randomized block design with three replications. Released varieties, international differentials as well as some cultures developed at CRRI, cuttack; AICRIP, Hyderabad and Raipur were included int he study.

To inoculate rice genotypes bacterial suspension was prepared from the bacterial culture of *Xanthomonas oryzae.* pv *oryzae* local isolate - '6R' which was prepared from PSA (potato sucrose Agar) slants using distilled water by modified Wakimoto's method. Seventy two hours old culture was used for inoculation. Suspension was adjusted to 1-1.5 OD (optical density) for inoculating plants. Clipping method suggested by Kauffman *et al.* (1973) was followed for inoculation. This method favoured the direct entry of the pathogen into xylem vessels. Top 4-6 leaves from each plant were clipped, 2-4 cm from the tip by dipping the scissor in the bacterial suspension. About 20-25 plants for each parents in every replication were inoculated late in the evening.

Disease reaction of these genotypes scored after 21 days of inoculation by following 0-9 scale of standard evaluation system of IRRI (1988). Weather condition were highly favourable for disease development during the screening period.

Screening results of 40 genotypes of rice tested against bacterial blight pathogen isolate-'6R' are presented in Table 1. Among the 40 genotypes screened, 25 entries viz. BG 400-1, Cr 683-310, Dular, IET 8585,

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Table 1. Reaction of some rice genotypes against bacterial blight pathogen isolate-6R, at Raipur

Genotype	Disease score (0-9)	Reaction
BG 400-1, CR 683-310, DULAR, IET 8585, TR 54, IRBB-1, IRBB-3, OR650-7, R4 35-68, R4 35-756, 5704-274-2-3, R712-1-65-2-2, R7 14-1-19-1-2, R714-1-19-1-3, R731-1-73-2-1, R732-2-49-2-2, R738-1-64-2-1, R738-1-64-2-2, R741-1-40-3-3, R741-1-55-2-2, R744-1-107-2-2, R744-1-107-2-3, RP2151-33-2, RP2151-64-3-1-1 and RP2151-733 BR	1	Resistant
I68-2B-23, CN846-30-3-1, IR40931-33-1-3-2, Kaurm-7, ORI284-9-2-1, R296-260-1-4, R650-1820, R746-2-34-1-2 and PDR 8702 IR 1545-339-	3	Moderate Resistant
IR 1545-339-2-2 and Madhuri	5	Moderate Susceptible
IET 6286, IET 10 and CR 661-414	7	Susceptible
MW-10	9	Highly Susceptible

TR 54, IRBB-1, IRBB-3, OR650-7, R4 35-68, R4 35-756, 5704-274-2-3, R712-1-65-2-2, R714-1-19-1-2, R714-1-19-1-3, R731-1-73-2-1, R732-2-49-2-2, R738-1-64-2-1, R738-1-64-2-2, R741-1-40-3-3, R741-1-55-2-2, R744-1-107-2-2, R744-1-107-2-3, RP2151-33-2, RP2151-64-3-1-1 and RP2151-733 were resistant (Score-1); 9 entries viz. BRI68-2B-23, CN846-30-3-1, IR40931-33-1-3-2, Kaurm-7, ORI284-9-2-1, R296-260-1-4, R650-1820, R746-2-34-1-2 and PDR 8702 were found to be moderately resistant (Score-3); 2 entries viz.IR1545-339-2-2 and Madhuri were moderately susceptible (Score-5); 3 entries viz. IET6286, IET 10810 and CR 662-414 were susceptible (Score-7) and one test entry MW-10 was observed to be highly susceptible (Score-9).

These identified resistant genotypes may be used as resistant donor.

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EFFECT OF SULPHUR ON GROWTH PARAMETERS AND YIELD OF SOME SELECTED CROPS

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Role of sulphur (S) in plant nutrition is well documented (e.g. Marschner, 1995). Sulphur is becoming increasingly improtant for Indian agriculture and is recognised as the fourth major nutrient. Sulphur deficiency can occur in any type of soil but there has been growing incidences of S deficiency in light textured soils with poor organic matter contents. Sulphur deficiency is known to reduce crop yields upto 35 per cent (Pal and Singh, 1992) even without expressing visual symptoms on plants. Plant species also vary markedly in their magnitude of responses to S application (Tandon, 1995). Thus, it appeared pertinent to evaluate the comparative responses of different crops. The present work aims at studying the effect of applied S on plant growth and yield of some selected rainy season crops.

A field experiment was conducted at Agronomy Farm. SKN College of Agriculture, Jobner during rainy season of 1998. The 20 treatments comprising of five crops typical of semi-arid situation (cowpea, clusterbean, pearlmillet, castor and sesame and four levels of S (0, 20, 40 and 60 kg S ha^{-1}), were tested in split plot design with 4 replications. The soil was loamy sand in texture with EC$_0$ 1.3 dSm^{-1}, pH 8.4, available N 130 kg ha^{-1}, K 150 kg ha^{-1} and S 8.1 ppm. Nitrogen and phosphorus were applied through urea and DAP in accordance with the recommended doses for the crops. Sulphur was applied through gypsum (15% S) as per treatment and then incorporated in soil. Crops were sown in mid of July after onset of *monsoon*. Total seasonal rainfall was 170 mm. Therefore, castor required two irrigations and the other crops needed one life saving irrigation.

Results revealed that sulphur fertilization increased the plant height of all the crops (Fig. 1). Pearlmillet plants were tallest followed by castor. Obviously, it was due to nature of crops. The increase in plant height may be attributed to better nutritional environment as a results of S application to a deficient soil. The increasing levels of S also increased the dry matter accumulation per plant (Fig. 2). The reason for increased dry matter production consequent upon S supply can be greater synthesis of chlorophyll (Singh and Singh, 1983) that might have aided in capturing more insolation. These results are in conformity with those of Gupta *et al.* 1993. Supply of S also helped in floral primordial initiation that evidetly resulted in higher number of pods or earheads per plant and seeds per pod or earhead (Table 1) and ultimately resulted in enhanced seed yield (Table 2).

Table 1. Effect of levels of sulphur on number of pods or earheads per plant and seeds per pod or earhead

	No of pods earheads					No of seeds per pod or earhead				
Crop	0	20	40	60	Mean	0	20	40	60	Mean
Cowpea	9.6	10.8	11.8	12.6	11.2	10.1	10.9	11.5	12.0	11.1
Clusterbean	36.9	41.0	44.7	46.4	42.2	8.0	8.6	9.0	9.3	8.7
Pearlmillet	2.2	2.4	2.5	2.6	2.4	1524.7	1632.9	1728.4	1794.9	1670.2
Castor	97.9	111.4	122.1	129.3	115.2	3.0	3.0	3.0	3.0	3.0
Sesame	37.6	42.1	43.5	43.7	41.8	49.2	52.1	53.3	53.9	52.1
Mean	36.8	41.5	44.9		319.0	341.5	361.1	374.6		
SEm±	1.25^{α}	1.10^{β}	3.49^{γ}	3.27l$^{\lambda}$	6.61^{α}	5.72^{β}	18.08^{γ}	16.99^{λ}		
C.D. 5%	3.86	3.15	7.04	6.88		20.38	16.30	36.44	34.99	

Table 2. Effect of levels of sulphur on grain and pearlmillet equivalent yield

	Grain yield (q ha^{-1})					Pearlmillet equivalent yied (q ha^{-1})				
Crop	0	20	40	60	Mean	0	20	40	60	Mean
Cowpea	8.3	9.8	11.0	12.0	10.3	16.5	19.6	22.1	24.0	20.5
Clusterbean	11.4	13.1	14.4	15.0	13.5	59.9	68.8	75.8	78.9	70.8
Pearlmillet	17.3	19.6	21.6	22.5	20.3	17.3	19.6	21.6	22.5	20.3
Castor	12.0	14.3	15.8	16.7	14.7	30.1	36.6	39.5	41.6	36.7
Sesame	4.7	5.5	5.9	6.0	5.5	27.1	31.4	36.7	34.5	31.7
Mean	10.8	12.4	13.8	14.4		30.2	35.0	38.5	40.3	
SEm±	0.32^{α}	0.27^{β}	0.84^{γ}	0.79^{λ}		1.11^{α}	0.95^{β}	3.01^{γ}	2.83^{λ}	
C.D. at 5%	0.97	0.76	NS	NS		3.43	2.71	NS	NS	

α = For main effect of crops, β=for main effect of sulphur, γ=when crop is same but sulphur at different levels, λ=when sulphur at same level but crops are different or both are different, NS=non-significant

A critical examination of data (Table 2) indicated that application of S had remarkable positive effect on the yields of all the crops. However, the quantum of increase in yield as a result of 60 kg S ha^{-1} varied greatly ranging from 27 per cent (sesame) to 45 per cent (cowpea). Sulphur supply at 20, 40 and 60 kg ha^{-1} increased the seed yield by 19, 34 and 45 per cent over control in cowpea. The corresponding figures for clusterbean, pearlmillet, castor and sesame were 15, 26, 32; 13, 25, 30; 18, 31, 38 and 16, 24, 27 per cent over control, respectively. The main effect of S further showed that application of S at 40 kg ha^{-1} produced an average grain yield of 13.8 q ha^{-1} which was significantly superior ot that at control (10.8 q ha^{-1}). The

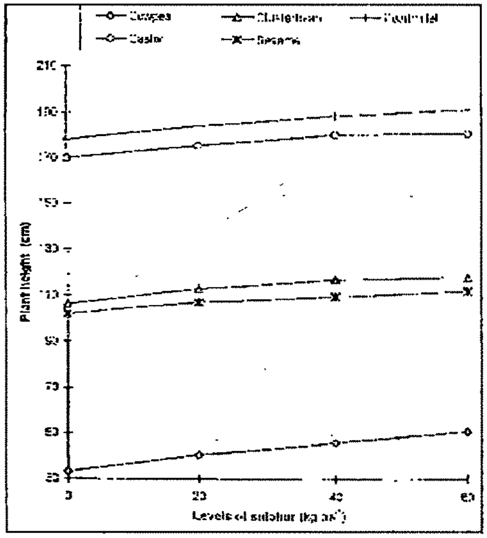

Fig. 1. Effect of S on plant height

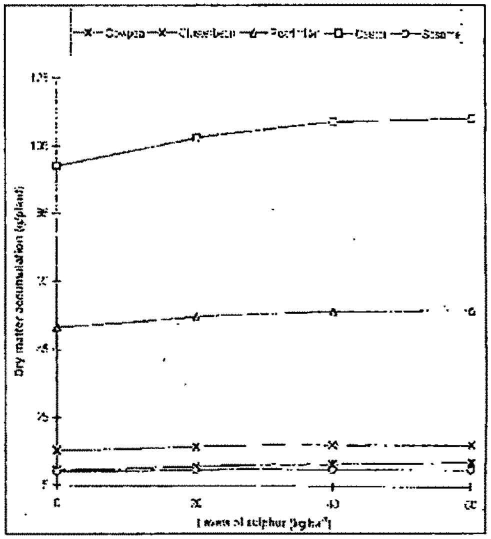

Fig. 2. Effect of S on dry matter accumulation

difference between the yields obtained at 60 or 40 kg S ha^{-1} was statistically not significatn. Although higher grain yield was produced in pearlmillet but pearlmillet equivalent yield was higher in clusterbean followed by castor. The result of present study are in agreement with those of Bansal (1991) who also reported increased yield due to S fertilization in different crops.

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EFFECT OF RHIZOBIUM INOCULATION, NITROGEN AND PHOSPHORUS ON ROOT NODULATION, PROTEIN PRODUCTION AND NUTRIENT UPTAKE IN COWPEA (*VIGNA SINENSIS SAVI)*

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Among crops grown in predominately vegetarian country like India, the important pulse crop as a source of protein hardly needs any emphasis. Amongest these, cowpea (Vigna sinensis Savi), is most nutritive pulse crop containing about 24.6% crude protein. It has been recognized as a very delicious and cheapest source of vegetable both for green pods and seeds and number of dishes prepared for which cowpea is mainly grown in India.

Legumes not only meet the nitrogen demand through atmospheric N fixation but also improve the productivity of soils. However, the extent of N fixation is governed by many factors like crop and soil management particularly of the nutrient. Cowpea occupies a prominent position as summer crop (zaied) of northern India. Nitrogen and phosphorus are known to have a great impact on nodulation and in turn of productivity of cowpea crop. Therefore, the present investigation was conducted to study the effect of rhizobium inoculation, nitrogen and phosphorus on short duration cowpea.

Materials and Methods

A field experiment was conducted during summers at Agricultural Research Farm of A.S. College, Lakhaoti, Bulandshahr (U.P.). The soil was sandy loam having low organic (0.18%) and available N (160.4 kg/ha), medium available P (16.4 kg/ha) and K (240.4 kg/ha) with pH 8.2. Cowpea cv. Pusa Komal was tested with 6 levels of N viz., kg N/ha(control), seed inoculation alone, 20 kg N/ha, 20 kg N/ha+seed inoculation, 40 kg. N/ha and 40 kg N/ha + seed inoculation in the form of urea and 4 phosphorus levels i.e. 0 kg P_2O_5/ha (control) 30, 60 and 90 kg P_2O_5/ha in the form of single super phosphate. The land was prepared after giving a light irrigation followed by discing and planking. The experiment was laidout in the randomized block design and replicated thrice. The plot size was 3.6 x 6.0 mtrs. Full doses on N and P were applied at the time of sowing alongwith of K at the rate of 50-kg K_2O/ha in the form of potash. Seeds of cowpea cv. Pusa Komal were treated with rhizobium culture prior to sowing and dried under shade. Seeds were sown in furrows 45 cm apart with the help of hand plough in the first week of March in both the seasons.

B.H.C. (10%) dust @ 25 kg/ha was applied as prophylatic measures against soil pest and it was well incorporated into the soil during the last harrowing. The crop given two irrigation in both the years. First irrigation was given after sowing and another fifteen days interval. The plots were kept weed free by manual weeding till grain filling.

Six tagged plants were taken randomly from each treatment and all growth and yield related observations were recorded from the selected plants. The crop was harvested manually after the maturity of pods and threshed by using a mechanical thresher. The harvest index was calculated as a ratio between seed yield and total above ground biomass multiplied by 100. Data wee recorded on plant growth and seed yield parameters and statistical analysis was done.

RESULTS AND DISCUSSION

Nitrogen and rhizobium inoculation

Number of nodules per plant, length of primary root and dry weight of root including nodules (Table 1) showed significant variation owing to nitrogen and rhizobium inoculation. Nodules/plant, root length and dry weight of root including nodules increased with N application upto 20 kg/ha. Rhizobium inoculation increased all the above parameters (nodules/plant, root length and dry weight of root including nodules) with levels of N upto 20 kg/ha, with a decline with further higher dose, possibly due to inhibitory action of fertilizer N on rhizobium. Jain *et al.* (1988) reported increased nodulation with rhizobium. rhizobium inoculation was most effective with 20 kg N/ha compared with 0 and 40 kg N/ha. A need of starter N dose for legumes was also realized by Gondalia *et al.* (1988). There was remarkable effect of nitrogen on seed, stover as well as total produce of cowpea in both the seasons. Table 2 showed that all the levels of nitrogen registered their superiority over control. The highest seed yield, stover yield and total produce was recorded in the crop fertilized with 20 kg N/ha alongwith rhizobium inoculation, through it remained at par with 40 kg N/ha alone and alongwith R. inoculation and noticeably superior to others. The data given in Table 3 indicated all the levels of nitrogen including R. inoculation were significantly superior to control. Among these levels the, highest protein yield was produced under 20 kg N/ha + R. inoculation followed by 40 kg N/ha + R. inoculation and was superior to rest of the levels. Jain *et al.* (1988) also obtained similar results.

The N content in seed and stover (Table 4) varied significantly due to nitrogen and inoculation treatment. Crop fertilized with 20 kg N/ha along with R. inoculation had the highest N content in seed and stover, through it was at par with 40 kg N/ha + R. inoculation, 40 kg N/ha alone and 20 kg N/ha alone. In N uptake (seed, stover and total) data showed that all the levels of nitrogen resulted in significantly higher accumulation was observed under 20 kg N/ha + R. inoculation being significantly superior to rest of the levels. Singh *et al* (1985) did also noticed such trend.

Significance variation in P content of seed and stover (Table 5) revealed that the P content increased with increasing N levels upto 20 kg/ha along with inoculation> Crop sown with inoculated seed and 20 kg/ha had significantly highest P content. Cumulative effect of increase in P content and drymatter yields might have resulted in increase in P uptake (seed, stem and total) with increasing N level upto 20 kg/ha along with inoculation.

Table 1. Effect of nitrogen, rhizobium inoculation and phosphorus on number of nodules per plant, length of primary root (cm) and dry weight of root including nodules per plant

Treatments	Number of nodules per plant		Length of primary root (cm)		Dryweught of root Including nodules	
Nitrogen Levels						
g n/ha (control)	2.4	3.4	12.8	12.1	0.94	1.00
seed inoculation alone	6.7	8.0	14.5	14.3	1.09	1.63
20 kg n/ha	7.0	7.4	13.9	13.7	0.95	1.54
20 kg n/ha-+ Seed inoculation	9.5	12.2	15.3	15.0	1.13	1.80
40 kg n/ha	8.0	8.7	15.1	14.8	0.99	1.56
40 kg n/ha + Seed inoculation	8.4	9.1	15.2	14.9	1.10	1.75
C.D. at 5%	0.12	0.1	0.3	0.3	0.03	0.05
Phosphorus levels						
0 Kg P_2O_5/ha	2.9	3.7	14.0	14.0	0.70	1.20
30 Kg P_2O_5/ha	3.9	4.6	14.1	14.0	0.88	1.58
60 Kg P_2O_5/ha	8.8	10.4	14.5	13.8	1.08	1.65
90 Kg P_2O_5/ha	10.0	12.0	14.9	14.7	1.30	1.74
C.D. at 5%	0.1	0.1	0.3	NS	0.27	0.12

Table 2. Effect of nitrogen, rhizobium inoculation and phosphorus on seed, stover and total produce yield (q/ha)

	Yield q/ha					
Treatments	Seed		Stover		Total produce	
Nitrogen Levels						
oKg n/ha (control)	17.24	21.61	40.12	44.88	57.36	67.49
seed inoculation alone	18.29	22.21	43.48	46.17	61.77	68.38
20 kg n/ha	18.17	22.10	42.29	45.97	60.46	68.07
20 kg n/ha-+ Seed inoculation	19.87	23.54	46.10	48.76	65.97	70.30
40 kg n/ha	19.70	23.28	45.83	47.39	65.53	69.67
40 kg n/ha + Seed inoculation	19.85	23.33	45.58	47.58	65.75	69.91
C.D. at 5%	0.25	0.41	0.42	0.43	0.50	1.24
Phosphorus levels						
0 kg p_2o_5/ha	17.75	21.26	41.41	42.93	61.26	67.19
30 kg p_2o_5/ha	18.84	22.76	43.04	46.23	62.83	68.99
60 kg p_2o_5/ha	19.98	24.01	46.46	49.12	64.54	70.73
90 kg p_2o_5/ha	18.94	22.50	44.90	47.02	65.81	72.02
C.D. at 5%	0.18	0.29	0.30	0.03	0.36	0.88

Table 3. Effect of nitrogen, rhizobium, inoculation and phosphorus on protein production (q/ha)

	Protein production (q/ha)					
Treatments	Seed		Stover		Total produce	
Nitrogen Levels						
oKg n/ha (control)	3.54	4.02	2.49	2.57	7.56	6.59
seed inoculation alone	4.21	4.97	3.21	3.33	7.42	8.30
20 kg n/ha	3.69	4.19	2.02	2.91	6.51	7.10
20 kg n/ha-+ Seed inoculation	4.40	5.00	3.54	3.60	7.94	8.60
40 kg n/ha	3.72	4.23	2.88	2.98	6.60	7.21
40 kg n/ha + Seed inoculation	4.32	4.95	3.52	3.58	7.84	8.53
C.D.'at 5%	0.09	0.09	0.05	0.04	0.10	0.06
Phosphorus levels						
0 kg p_2o_5/ha	3.50	3.80	2.90	2.92	6.40	6.72
30 kg p_2o_5/ha	3.55	3.84	2.91	2.95	6.46	6.79
60 kg p_2o_5/ha	4.04	4.72	3.02	3.18	7.06	7.90
90 kg p_2o_5/ha	4.35	5.14	3.25	3.37	7.60	8.51
C.D. at 5%	0.06	0.07	0.03	0.03	0.09	0.03

Table 4. Effect of nitrogen, rhizobium, inoculation and phosphorus on nitrogen content in plant and uptake by cowpea

	N content (%)				N Uptake (Kg/ha)					
Treatments	Seed		Stover		Seed		Stover		Total Produce	
Nitrogen Levels										
Okg N/ha (control)	3.84	3.83	1.21	1.17	66.20	82.76	48.54	53.68	119.88	136.43
Seed inoculation alone	4.05	4.10	1.35	1.34	74.07	91.06	58.69	61.86	132.76	152.92
20 kg N/ha	3.92	3.95	1.30	1.25	71.23	87.30	54.98	57.46	126.21	144.76
20 kg N/ha-+Seed inoculation	4.15	4.18	1.40	1.37	82.46	98.39	64.54	64.06	147.00	162.45
40 kg N/ha	3.95	4.00	1.32	1.26	77.81	93.12	60.49	58.45	138.30	151.57
40 kg N/ha + Seed inoculation	4.05	4.11	1.35	1.36	80.39	95.88	61.69	63.35	142.35	159.23
C.D. at 5%	0.05	0.06	0.06	0.06	0.06	0.43	0.25	0.38	1.42	3.15
Phosphorus levels										
0 kg P_2O_5/ha	3.70	3.73	1.10	1.06	65.67	79.30	47.75	48.68	113.42	127.98
30 kg P_2O_5/ha	3.90	3.92	1.21	1.17	73.48	89.22	53.11	54.09	126.59	143.31
60 kg P_2O_5/ha	4.02	4.03	1.31	1.31	80.32	96.76	58.24	61.20	138.56	157.95
90 kg P_2O_5/ha	4.06	4.13	1.38	1.35	84.45	103.25	62.11	63.48	146.56	166.73
C.D. at 5%	0.03	0.45	0.05	0.05	0.43	0.31	0.17	0.27	3.3	3.6

Table 4. Effect of nitrogen, rhizobium, inoculation and phosphorus on nitrogen content in plant and uptake by cowpea

	P content (%)				P uptake (kg/ha)					
Treatments	Seed		Stover		Seed		Stover		Total k	
Nitrogen Levels										
0Kg n/ha (Control)	0.397	0.382	0.077	0.076	6.84	8.26	3.08	3.49	9.92	11.75
seed inoculation alone	0.406	0.409	0.081	0.081	7.43	9.08	3.52	3.74	10.95	12.82
20 kg n/ha	0.398	0.386	0.078	0.077	7.21	8.53	3.29	3.54	10.52	12.07
20 kg n/ha-+ Seed inoculation	0.490	0.416	0.084	0.084	9.74	9.79	3.87	3.93	13.61	13.72
40 kg n/ha	0.399	0.398	0.079	0.079	7.86	9.27	3.62	3.66	11.62	12.93
40 kg N/ha + Seed inoculation	0.418	0.415	0.082	0.082	8.29	9.68	3.86	3.88	12.05	13.50
C.D. at 5%	0.003	0.003	0.003	0.003	0.17	0.23	0.03	0.06	0.11	0.22
Phosphorus levels										
0 kg P_2O_5/ha	0.396	0.402	0.074	0.074	7.29	8.55	3.21	3.39	10.50	11.94
30 kg P_2O_5/ha	0.400	0.405	0.076	0.076	7.54	9.22	3.34	3.51	10.88	12.73
60 kg P_2O_5/ha	0.404	0.409	0.080	0.080	8.07	9.82	3.56	3.74	11.63	13.56
90 kg P_2O_5/ha	0.415	0.400	0.084	0.085	8.63	10.50	3.78	3.99	11.63	13.56
C.D. at 5%	0.003	0.003	0.003	0.003	0.12	0.16	0.03	0.07	0.07	0.14

Phosphorus

Application of P influenced remarkably the number of nodules per plant, length of primary roots and dry weight of roots including nodules (Table 1). These parameters increased significantly with P application upto 90 kg/ha. It might have been due to increased efficiency of roots to extract water and nutrient from soil as reported by Ahlawat and Saraf (1981) and Singh *et al.* (1981). There was marked increased in yield (seed, stover and total produce) with each increase in phosphorus application upto 90 kg P_2O_5/ha in both the years (Table 2). Increase in yield might have been due to increase in yield attributes (seed, stover and total produce). As phosphorus is known to induce translocation of photosynthates towards reproductive parts by regulating vegetative growth of plants. Singh *et al.* (1985) were also of similar opinion. Phosphorus remarkably improved the quality of cowpea in terms of protein yield in seed with increasing levels of phosphorus from 0 kg (control) to 30kg, 30 to 60 kg and 60 to 90 kg P_2O_5/ha (Table 3). The similar trend was noticed for protein yield in stover and total produce during both the seasons.

The N content in seed and stover (Table 4) tended to increase with P fertilization. There was marked improvement in nitrogen content in both the seed and stover with increasing levels of phosphorus up to 90 kg P_2O_5/ha during cropping seasons. Additive effect of dry matter and N content increase might have resulted in significant increase in N uptake (seed, stover and total).

Application of P had significant effect on content and uptake of P (Table 5.) Both content and uptake tended to increase with P fertilization up to 90 kg P_2O_5/ha. The P content in seed as well as in stover in both the season registered significant increase up to 90 kg P_2O_5/ha. Singh *et al.* (1985) also reported similar results.

An experiment was conducted at A.S. College, Lakhaoti (Bulandshahr) U.P. during summer season to study the effect of rhizobium inoculation, nitrogen and phosphorus on root nodulation, protein production and N and P uptake in cowpea *(Vigna sinensis* Savi) on sandy loam soil. Root length as well as number of nodules increased upto 20 kg N/ha when applied with rhizobium inoculation. Response to P was up to 90 kg P_2O_5/ha. Rhizobium inoculation when applied with 0, 20 or 40 kg N/ha has proved its worth over respective sole N application. Almost similar trend was observed for protein production, N and P content as well as N and P uptake. The highest yield was recorded when 20 kg N/ha + rhizobium inoculation was applied along with 60 kg P_2O_5/ha.

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EFFECT OF PHOSPHORUS AND BIOFERTILIZERS ON YIELD AND YIELD ATTRIBUTES OF CLUSTER BEAN [*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB]

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Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] popularly known by its vernacular name 'Guar' is an important leguminous crop of *kharif* season in arid and semi arid regions of tropical India. In India, it occupies an area of 22.62 laka hectares with production of 6.48 lakh tones of seeds annually giving an average productivity of 286 kg/ha (Anon., 1992). The low productivity of the crop is mainly attributed to limited supply of essential nutrients especially N and P. Keeping this in view the present study was undertaken to assess the effect of phosphorus, *Rhizobium* and phosphate solubilizing bacteria (PSB) on yield and yield attributes of cluster bean.

A field experiment was conducted during *kharif* season of 1998 at Agronomy Farm of S.K.N. College of Agriculture, Jobner. The climate typically semiarid, characterized by extremes of temperatures both during summer and winter. The soil of experimental field was loamy sand in texture testing low organic carbon (0.22 per cent) and available N (129.79 kg/ha), medium in available P (16.01 kg/ha) and available potash (150.64 kg/ha), with pH 1:2 soil water suspension) 8.27.

The experimental treatments comprised of levels of phosphorus (0, 15, 30, 45 and 60, kg P_2O_5/ha) and inoculation of seed with *Rhizobium* and PSB alone and combined. The experiment was laid out in randomized block design with four replications. The crop was grown following the recommended package of agronomic practices and adequate plant protection measures were taken.

The number of pods per plant, seeds per pod, pod length (cm) and test weight were significantly increased due to phosphorus application over control. Application of 45 kg/ha being at par with 60 kg P_2O_5/ha gave significantly higher number of pods per plant, seeds per pod, pod length and test weight compared to other treatments. There was significant increase in seed yield due to increasing levels of phosphorus up to 45 kg/ha while straw and biological yield up to 30 kg P_2O_5/ha only (Table 1). It might be due to the fact that under adequate availability of nutrients more and more of it might have been taken up by plants for greater photosynthesis which ultimately increased plant growth and yield parameters and resulted in seed and straw yields. This also gains support from existence of highly significant and positive correlation between seed yield and pod number (r=0.97), seed per pod (r=0.96), pod length (=0.97) and test weight (r = 0.96). From regression studies (Table 2) it was observed that a unit increase in yield attributes, viz., pods per plant, seeds per pod, length and test weight increased seed yield by 39.28, 173.13 and 42.74 kg/ha, respectively.

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Seed treatment with *Rhizobium*, PSB and *Rhizobium*+PSB significantly increased pods plant, seeds per pod, pod length, test weight as well as seed and straw yield over no inoculation (Table 1). The increase in seed and straw yield is due to the cumulative effect of increased growth and yield attributes. The combined inoculation of *Rhizobium*+PSB significantly enhanced the yield attributes and yield of cluster bean over control and *Rhizobium* alone. The results obtained are in line with the findings of Gaind and Gaur (1992), Tomar *et al.* (1993). The

Table 1. Effect of phosphorus and biofertilizers on yield and yield attributes of cluster bean

Treatments	Pods/ plant	Seeds/ pod	Pod length (cm)	Test weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest uindex (%)
Phosphorus (kg P_2O_5/ha)							
0	27.41	5.40	6.43	25.15	10.14	28.48	25.66
15	30.12	6.49	6.99	27.57	12.06	31.68	26.71
30	32.99	7.32	7.53	29.81	13.22	33.02	27.83
45	35.50	8.59	8.07	32.50	13.90	33.71	28.26
60	36.57	8.62	8.18	33.20	13.98	33.92	28.83
C.D. at 5%	2.43	0.64	0.52	2.01	0.60	1.29	NS
Biofertilizers							
Control	28.50	6.51	6.92	27.24	11.24	29.29	28.07
Rhizobium	31.20	7.20	7.40	29.80	12.86	32.33	28.34
PSB	34.23	7.60	7.65	30.70	13.08	32.91	28.43
Rhizobium + PSB	34.94	7.69	7.79	30.80	13.26	33.47	28.45
C.D. at 5%	2.18	0.57	0.46	1.80	0.54	1.15	NS

Table 2. Correlation coefficients for seed yield (q/ha) v/s yield attributes and regression equation

Seed yield (Y) v/s	Correlation coefficicent	Regression equation
Number of pods per plant (X)	0.97**	Y=0.48+39.28X
Number of grains per pod	0.96**	Y=7.37+173.13X
Pod length (cm) (X)	0.97**	Y=-2.37+170.48X
Test weight (X)	0.96**	Y=-152.8+42.74X

synergistic effect of *Rhizobium* and PSB in enhancing the growth, yield attributes and ultimately yield might due to increased nitrogenase activity and available P status of soil. Similar findings were reported by Dubey (1996).

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COMPARATIVE MANURIAL PERFORMANCE OF FYM, BIOGAS SLURRY AND SEWAGE SLUDGE

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Organic manures including sewage sludge and biogas slurry are important for improving soil health and mitigating the deteterious effects of inorganic fertilizers on physico-chemical characteristics of the soil (Bouldin, 1988). However, their relative influence may very and keeping this a view in present investigation was undertaken. A pot culture experiment was conducted with brinjal and tomato crops for ascertaining the comparative manurial value of FYM, biogas slurry and sewage sludge at Water Technology Centre, IARI, New Delhi during 1993-94. Sandy loam soil collected from IARI Research Farm was used for pots. It contained sand (65.2%), silt (12.0%), clay (22.8%) and classified as Typic Ustocbrept was non-saline (ECe=0.4 dS m^{-1} and non-calcareous in nature. Available nitrogen, phosphorus and potassium levels were 148.0, 15.9 and 262.7 kg ha^{-1}, respectively. twenty kg of well processed soil was filled in china clay glazed pots of 52 cm × 23 cm × 22 cm dimensions. Organic amendments of FYM, biogas slurry and sewage sludge were mixed @ 5,10 and 15 t ha^{-1} alongwith urea and single superphosphate in grades of N-P_2O_5 ha^{-1} as 0-0, 40-20, 80-40 and 120-60. There were 36 treatments (3x3x4) comprising of 3 manures, 3 levels and 4 fertilizers combinations with three replicates. Some physico-chemical characteristics of organic manures are given in Table 1.

Brinjal (var. Pusa Kranti) and tomato (var. Pusa Ruby) seedlings of about 25 days old were transplanted in pots in first week of October 1993 and March 1994 and harvested in last week of Januray and May, 1994, respectively. Dry matter and fruit yield was recorded and plant samples were analysed for N,P,K (Parkinson and Allen, 1975). Yield of fresh fruits and dry samples were analysed for N,P, K (Parkinson and Allen, 1975). Yield of fresh fruits and dry matter as influenced by different organic manures, their levels and fertilizer doses depicted in Fig. 1. On an average, 30.4 and 32.4 per cent more yield was recorded in brinjal and tomato, respectively with the sewage sludge as compared to FYM. Magnitude of increase was more in case of dry matter yield than the fresh fruit yield in both the crops. Application of sewage sludge registered an increase of 67 and 70 per cent in brinjal and tomato, respectively over FYM. Highest dose of 15 t ha^{-1} of all the organic manures produced significantly higher yield in case of both brinjal and tomato plants. Further, application of 120-60 kg ha^{-1} of N-P combination produced fruit yield to the tune of 215.6 and 285.9 g pot^{-1} of brinjal and tomato, respectively followed by lower doses of N-P fertilizers.

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Table 1. Characteristics of organic manures

Characteristics	Sewage sludge	FYM	Biogas slurry
pH	6.70	7.67	7.58
EC (d Sm^{-1})	2.30	0.96	1.60
Nitrogen (%)	1.58	0.52	1.20
Phosphorus (%)	1.25	0.33	1.05
Potash (%)	0.50	0.45	0.76
Organic carbon (%)	31.70	16.40	25.00
C/N	16.00	26.20	20.80
Total micronutrients (ppm)			
Zn	2450	267	603
Fe	465	174	220
Cu	265	20	12
Mn	458	204	251

Table 2. Effect of organic manures and fertilizers on nutrient uptake (g pot^{-1}) by brinjal and tomato

Treatments	N		P		K	
	Brinjal	Tomato	Brinjal	Tomato	Brinjal	Tomato
Organic manures						
Sludge	1.22	0.69	0.16	0.09	0.83	0.46
FYM	0.69	0.37	0.09	0.05	0.44	0.24
Slurry	0.82	0.46	0.11	0.06	0.55	0.31
C.D. (P=0.05)	0.04	0.02	0.07	0.04	0.04	0.02
Manures rate (t ha^{-1})						
5	0.75	0.42	0.10	0.05	0.50	0.28
10	0.91	0.51	0.12	0.07	0.61	0.34
15	1.04	0.59	0.14	0.08	0.71	0.39
C.D. (P=0.05)	0.04	0.02	0.007	0.004	0.04	0.02
Inorganic fertilizer (kg ha^{-1})						
00.00	0.62	0.35	0.08	0.046	0.41	0.23
40-20	0.79	0.45	0.10	0.059	0.53	0.30
80-40	1.02	0.57	0.13	0.076	0.68	0.38
120-60	1.17	0.66	0.16	0.089	0.81	0.44
C.D. (P=0.05)s	0.05	0.03	0.008	0.005	0.05	0.06

Nutrients uptake

Total uptake of nitrogen, phosphorus and potash by brinjal and tomato plants as influenced by different organic manures, their doses with N-P grade is given in Table 2. Response trend as reported in dry matter and yield parameters was also reflected in uptake behavior of the nutrients. Total uptake of N, P and K with sewage sludge was 1.22, 0.16 and 0.83 by brinjal and 0.69, 0.09 and 0.46 g pot^{-1} by tomato, respectively followed by biogas slurry and FYM. Differences in magnirude of uptake among the different manures were statistically significant in both the crops. Application of highest dose (15 t ha^{-1}) induced 1.04 and 0.59 g pot^{-1} of nitrogen uptake by brinjal and tomato plants, respectively. Similar uptake of phosphorus and potash was also increased significantly with higher dose of organic manuresin case of both the crops. Interaction of organics oversees and N-P combinations caused significantly higher uptake of the nutrients. Application of organic manures caused better plant growth and that finally led to higher uptake of these nutrients by the plants of both the crops. Moreover, better nutritional atmopshere of ryzosphere with respect to micro-nutrietns (Table 1) might have increased the root cation exchange capacity which subsequently led to increase in nutrients uptake (Mote *et al.* 1983).

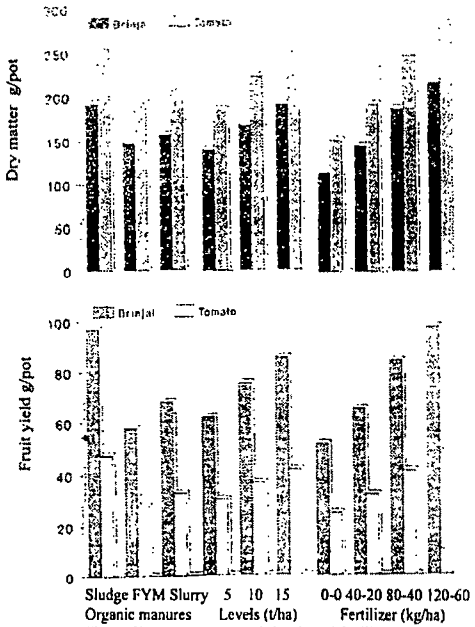

Fig 1 Effect of manures, their levels and fertilizer doses on yield and dry matter of brinjal and tomato

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INOCULATION WITH *BRADYRHIZOBIUM* JAPONICUM FLUORESCENT *PSEUDOMONAS* TO CONTROL *RHIZOCTONIA SOLANI* IN SOYBEAN [*GLYCINE MAX* (L) MERR]

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Apart form directly affecting plant growth, the fluorescent *Pseudomonas* have also been shown to suppress the soil borne pathogenic infection and /or host susceptibility to disease (Kloepper, 1993). Like *Pseudomonas,* some fast growing strains of *Bradyrhizobium japonicum* are known to produce bacteriocins called rhizobiotoxin and have the potential to reduce the severity of seed and root decay disease. Similarly *Bradyrhizobium japonicum* and Fluorescent *Pseudomonas* interaction have been reported to produce synergistic effect on disease control and plant growth (Vidhyasakaran and Muthamilan, 1995). In view of above apparent significance the present study was undertaken to find out the effect of inoculation with selected strains of fluorescent *Pseudomonas. Bradyrhizobium japonicum Rhizoctonia, Solani* and their interaction on disease control, seed emergence, plant growth, nodulation and nutrients (N,P, Zn, and Mn) uptake soybean under unstriated pot condition.

A pot experiment was conducted in glass house during August 1995 to December 1995. During the experimental period, the temperature and humidity of glass house chamber varied from 28.2± 2° C to 33 ± 2° C and 65 to 90%, respectively. The plastic pots (15 cm x 15 cm) were filled with Mollishol having silty clay loam texture with pH 7.1. *B. japonicum* strain SB-12, *fluorescent Pseudomonas* strain JLoZ-3, *Rhizoctonia solani* and their possible interactions were tested in triplicate using a Complete Randomized Design. An uninoculated control was also included in the study. Ten healthy and bold seeds of soybean (Cv - Pk - 472) were sown in each pot. Before covering the seeds with small amount of soil, each seed was individually inoculated by pouring 1 ml each of *Pseudomonas* - JLo Z-3 (2.8 x 105 cfu ml^{-1}), *B. japonicum* SB-12 (1.5 x 108 cfu ml^{-1}) and *Rhizoctoni solani* (3.4 x 104 cfu ml^{-1}) as per treatment. After counting germination at 6 days after sowing (DAS) and plants stand count at 10 DAS, the plant were thinned to 3 plants per pot. The experiment was terminated at 30 DAS. Length of root and shoot were measured and then the nodule were separated and counted. Dry weight of root, shoot and nodules were recorded after drying them to constant weight at 70°C in an oven.

The plant samples were ground to analyse amount of nutrients viz N,P, Zn. Fe and Mn present in the plant sample. The determination of N in plant samples was done by Micrological method. The wet digestion (Jackson, 1973) of plant material was done for the determination of P, Zn, Fe and Mn in each plant sample. The

Table 1. Effect of inoculation with *Bradyrhizobium joponicum* - SB - 12, fluorescent *Pseudononas* JLoZ-3, *Rhizoctonia solani* and their interactions on seed fermination, plant stand count, disease incidence, plant growth, nodulation and nutrients uptake of soybean at 30 DAS

Straain (s)	Seed Germi-nated (%)	Seed Rotten (%)	Seedling stand (%)	Abnorml seedling (%)	Shoot length (cm./ plant)	Shoot dry wet (mg/ plant)	Root nemgth (cm./ plant)	Root dry wt. (mg/ plant)	No. of nodulles (prt plant)	Nodulles dry out (mg/ plant)	NodullesNutrients uptake 30 days				
											N (mg/ plant)	P (mg/ plant)	Zn (µg/ plant)	Fe (µg/ plant)	Mn (µg/ plant)
Uninoculated control	80.00 (63.92)	20.00 (26.07)	76.66 (61.21)	0.00 (0.00)	25.90	329	16.70	68	7.00	4.52	8.08	1.27	7.74	122.22	39.83
Pseudomonas - JLo Z-3	86.66 (72.28)	13.13 (17.71)	83.33 (66.14)	0.00 (0.00)	33.76	505	28.63	112	8.00	5.17	2.22	14.96	14.96	226.41	102.97
B.Japonicum. SB-12	83.33 (70.07)	16.00 (19.92)	80.00 (63.92)	0.00 (0.00)	30.73	468	21.70	86	10.66	7.26	11.96	1.87	11.49	189.42	73.78
R.solani	53.33 (46.92)	46.66 (43.07)	43.33 (41.15)	43.33 (41.33)	17.96	213	13.26	44	2.16	1.50	5.38	0.78	3.83	89 18	18.39
JLo Z -3 SB -12	96.66 (83.85)	03.33 (6.14)	96.66 (83.85)	0.00 (0.00)	41.59	579	36.93	148	13.50	10.48	17.67	2.71	23.77	288.26	132.37
JLo Z - 3 x R. Solani	66.66 (54.78)	33.33 (35.21)	60.00 (50.85)	23.33 (28.78)	22.16	270	15.56	92	5.16	3.52	7.87	1.24	7.36	126.12	45.08
SB - 12XR. solani	63.33 (52.77)	36.66 (37.22)	56.66 (48.84)	33.33 (35.21)	20.50	253	14.03	80	6.16	4.20	6.97	1.17	6.50	125.06	38.17
JL0 Z - 3X SB - 12X R. solani	73.33 (59.00)	26.66 (30.99)	66.66 (54.78)	13.33 (21.14)	26.00	280	17.03	103	7.66	5.71	8.85	1.28	8.38	136.69	50.98
SEm±	5.634	5.634	3.337	1.580	0.280	11.35	0.22	4.66	0.56	1.28	0.29	0.04	0.29	5.49	1.70
C.D. (1%)	23.270	23.270	13.949	6.525	1.171	47.68	0.91	16.34	2.33	1.32	1.21	0.17	1.90	22.68	7.02
C.D. (5%)	16.893	16.892	10.125	4.737	0.85	34.74	0.66	12.73	1.69	0.957	0.87	0.13	0.87	16.46	5.09

(Angular transformed value within parenthesis) phosphorus in the digested material was determined by Molybdovanadate method (Jackson, 1973). The determination of Zn, Fe, and Mn was done with the help of Atomic absorption Spectro Photometer. The uptake of nutrients by plant were determined by multiplying the amount of nutrients with dry matter accumulation by plants at 30 DAS.

The data presented in the Table 1 show that the individual inoculation with *B. japonicum* SB-12 and fluorescent *Pesudomonas* JLoZ-3 considerably improved emergence and seedling stand and significantly increased length and dry matter accumulation in shoot and root, number of nodule and their dry matter and nutrients (N, P, Zn, Fe and Mn) uptake by soybean plants over uninoculated control. Whereas maximum seed emergance, plants growth, nodulation and nutrient uptake were recorded where the seeds were coinoculated with SB - 12 and JLoZ-3. The similar have been reported by Dileep Kumar and Dube (1992) and Smolin and Shabev (1992). The inoculation with *Rhizoctonia solani* alone significantly reduced the seed emergence and seedling stand, root and shoot length and their dry matter, nodule number and their dry weight and nutrients uptake over uninoculated control. The deleterious effect of pathogen *R. solani* reduced significantly when coinoculated either with B.*japonicum* SB-12 or with fluorescent *Pesudomonas* JLoZ - 3 registering remarkably increase in germination and significantly increased in seedling stand, dry matter accumulation and nutrients uptake over pathogen alone treatment. Further these findings are in conformity of the results obtained by Zaidi and Singh (2000) where fluorescent *Pesudomonas* JLoZ - 3 and *B. japonicum* SB-12 inhibited growth of *Rhizoctonia solani in vitro.* Klopper (1993) also reported increase in plant growth with PGPR inoculation by reducing population densities of DRMO's. The tripple inoculation with SB-2x JLo-3 x *R. solani* completely eliminated the ill effects of pathogen and recorded seed emergence, plant growth, nodulation and nutrients (N, P, Zn, Fe and Mn) up take with uninoculated control. The results may be attributed by providing competition free environment to soybean roots and Rhizobium due to suppression of *R. solania* and other DRMO's by antipathogenic and growth promoting activities of *Pesudomonas* JLoZ - 3 *B. japonicum*-SB-12. Similar results have also been reported by Balasundram and Sarbhoy (1998).

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DIVERSITY OF NATURAL ENEMIES OF INSECT PESTS IN UPAS - 120 CULTIVAR OF PIGEONPEA AT VARANASI

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The experiments were conducted at the Agriculture Research Farm, Banaras Hindu University, Varanasi, Pigeonpea variety UPAS 120 was grown during kharif seasons of 1994 and 1995. No plant protection measures were undertaken during the entire period of this experiment. The population of sac spider of pigeonpea insect pests was recorded by observing the randomly selected five plants from three middle rows of each plot at fortnightly interval.

The population data were used to compute the standard deviation (S.D.), variance (S^2), coefficient of variance of co-variance (C.V.), standard error (S.E.), variance density ratio (S^2/x) and fiducial intervals (Fi.I) with a view to understanding the fluctuation in the population.

The effect of climatic (abiotic) factors on the population build up of sac spider in the pigeonpea field was worked out by computing the simple correlation coefficient (r). For testing the significance of simple correlation coefficient 't' test was applied.

The natural enemies associated with insect-pests of the early cultivar of pigeonpea (UPAS-120) were of seven orders viz. Odonata (1 family), Dictyoptera (1 family), Hemiptera (1family) Neuroptera (1 family), Coleoptera (1 family), Hymenoptera (2 family) and Araneae (2 family). The insect families Gomphidae, Mantidae, Miridae, Chrysopidae, Coccinellidae, Eulophidae and Braconide and the spider families, Araneidae and Clubionidae were represented by one species each.

The natural enemies of pigeonpea pests observed in the field were braconid wasp (*Apanteles* sp), eulophid parasitoid (*Euderus lividus* Ashm.)], lady bird beetle (*Coccinella septempunctata* (Linn.)], bird bug (*Cyrtorhinus lividipennis),* praying mantid *(Mantis religiosa),* dragonfly [*Crocothemis servila* (Drury)], Green lacewings (*Chrysoperla carnea)* sca spider *(Clubiona* sp.) and spider (*Araneus* sp.).

Two species of spiders namely *Clubiona* sp. and *Araneus* sp. were found in UPAS-120 cultivar of pigeonpea. Among these two species, the sac spider was more prevalent and was found feeding on the leaf webber and legume pod borer. The first record of the sac spider was made on 23rd October (0.94 spider per five plants) having its peaks on 23rd November (2.33 spider per five plants) and disappeared after 22nd December (1.50 spider per five plants) The disappearance of the sac spider concided of the insect pests which may be attributed to the fact that the pigeonpea crop became mature and unfit for insect pests infestation. Singh and Mavi (1984) reported two spices of spiders i.e *Thomisus shivajiensis* and *Clubion abbottii* feeding on blue butterfly adult (*Lampides boeticus*) from Ludhiana, Punjab predator spider. The annual average population was 1.4 per five plants in 1994 and 0.8 per five plants in 1995. The spider population showed little variation ranging from 0.7 to 2.3 and 0.2 to 1.8 per five plants during 1994 and 1995, respectively. The temporal distribution showed significant difference during different years. The dispersion parameters indicated regular temporal population distribution as regular, which may be due to low population and less variation. The standard error varied from ± 0.4 to ± 0.6 and ±0.7 in the year 1994 and 1995, respectively. The coefficient of variation showed 37.6 per cent and 74.6 per cent in the year 1994 and 1995, respectively. The frequency of occurrence followed the pattern of abundance and it ranged from 55.6 to 100 per cent with an annul average of 74.5 per cent during 1994-95 and 22.2 to 94.4 per cent with an annual average of 51.1 per cent during 1995-96. The variance/density ratio was found to be 0.2 and 0.4 in the years 1994 and 1995, respectively. The effect of meteorological factors on the population of sac spider (*Clubiona* sp.) did not exhibit significant effect. However, sunshine hours of the preceding week showed significant positive impact on the spider population in case of pigeonpea cultivar UPAS-120. Spiders are the polyphagous predator and were found feeling in a variety of insect pests. Some times even the beneficial insects/natural enemies on insect pests were also trapped in the spider web and were eaten by them. However, spiders may be an effective tool against the pest complex if these spiders are conserved and encouraged by adopting pest management strategy.

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ESTIMATION OF GENETIC PARAMETERS AMONG A SET OF MUNGBEAN (*VIGNA RADIATA* L.) WILCZEK) GENOTYPES

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The experimental material comprising of 32 genotypes of mungbean were evaluated in randomized block design with three replications at Research Farm, College of Agriculture during kharif, 2000. Each genotype was grown in paired rows of 4m length with row to row and plant to plant distance as 40 and 10 cm, respectively. The observations were recorded for different characters namely, plant height (cm), number of primary branches per plant, days to 50 per cent flowering, number of pods per plant, pod length (cm), number of seeds per pod, 100-seed weight (g), biological (g), harvest index (%) and seed yield per plant (g). Analysis of variance and the genetic parameters were computed following standard statistical procedures.

The analysis of variance exhibited highly significant differences among 32 genotypes for all the 10 characters indicating the presence of genetic variability among the genotypes. The estimates of various genetic parameters are presented in Table 1. High range was observed for most of the characters viz., plant height, number of pods per plant, biological yield, harvest indeed and days to 50 per cent flowering. Comparatively narrow range was observed for the characters 100-seed weight, seed yield per plant, pod length, number of seeds per pod and number of primary branches per plant. In general, the magnitudes of the PCV were higher than those of GCV for all the characters. The estimates of GCV and PCV were high for the characters like seed yield per plant, biological yield and harvest index while moderate estimates of GCV and PCV recorded for the characters, number of pods per plant, plant height, 100-seed weight and number of primary branches per plant. Estimates of GCV and PCV were low for pod length, days to 50 per cent flowering and number of seeds per pod. The difference between estimates of PCV and GCV was low for the characters plant height, days to 50 per cent flowering, pod length and 100-seed weight showing thereby lesser role played by the environment in the expression of these characters, whereas the difference between estimates of PCV and GCV was high for the characters like biological yield per plant, number of pods per plant and number of seeds per pod indicating the significant role played by the genotype environment interaction (GXE) in the phenotypic expression of these characters. These results are supported by the findings of Reddy (1997) for plant height, pod length and number of seeds per pod.

The estimates of heritability were high for the characters plant height, seed yield per plant, 100-seed weight, days to 50 per cent flowering, harvest index and pod length whereas low heritability was recorded for number of seeds per pod. Accordingly, the characters, plant height, seed yield per plant, harvest index, 100-seed weight had high GCV and heritability indicating less environmental influence on these characters and their high transmission index. Reddy (1997) also observed similar results for yield per plant and plant height.

High estimates of genetic advance as per cent of mean was recorded for the characters, seed yield per plant followed by biological yield, harvest index, plant height 100 seed weight, number of pods per plant and number of primary branches per plant. This offers a good promise for effectivenes of selection based on these characters. For rest of the characters, the genetic advance was low. Inspite of high heritability pod length had low value of genetic advance thus heritability alone dose not necessarily mean an increase of genetic advance. The high heritability along with high genetic advance in a character suggest that phenotypic selection based on such a character is likely to be more efficient. In the present study, the high genetic advance as per cent of mean together with high heritability and GCV was noted for seed yield per plant, biological yield per plant height, harvest index, 100-seed weight and pods per plant indicating merit value of these characters. Therefore, simple direct selection could be effective for improving these characters. The high heritability with low genetic advance was observed for days to 50 per cent flowering and pod length which indicated more influence of non-additive gene effects and

Table 1. Estimates of genotypes and phenotyic coefficients of variation, heritability and genetic advance for 10 characters of mungbean

Characters	Range	Mean	GCV	PCV	h2	GA	GA (% of mean)
Plant height (cm)	2.7.80-52.9	39.6	21.27	22.12	0.925	16.67	42.09
Number of Primary branches per plant	1.40-3.33	2.	14.20	17.41	0.665	0.64	23.70
Days to 50 per cent flowering	41.66-48.33	45.0	4.75	5.21	0.829	4.00	8.88
Number of pods per plant	10.30-26.13	18.1	22.47	29.74	0.571	6.34	35.02
Pod length (cm)	6.66-8.26	7.4	5.34	6.14	0.756	0.71	0.59
Number of seeds per plant	8.90-11.50	10.3	4.06	7.11	0.326	0.49	4.75
100-seed weight	1.91-3.90	2.6	18.48	19.69	0.880	0.93	35.76
Biological yield (g)	2.19-17.73	8.9	36.07	44.46	0.658	5.33	59.88
Harvest index (%)	9.8-36.96	23.0	30.61	35.02	0.764	12.70	55.21
Seed yield per plant (g)	0.69-4.62	2.1	50.92	54.13	0.885	2.02	96.19

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INDUCED VARIABILITY OF NITROGEN METABOLISM ENZYMES IN *PHASEOLUS VULGARIS* L.

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French bean being a shy nodulator readily respond to high doseds of nitrogen. To maximize biologically fixed nitrogen attention must be paid to the plant related aspects of symbiotic process in plant breading program. Nitrate reductase and Glutamine synthetase ate the two key enzymes of nitrogen metabolism. In the present study an attempt has been made to test the mutants of *Phaseolus vulgaris* L. cv. PDR-14 in presence or absence of NO_3 to establish relationship with some bio-chemical and physiological parameters to that of nitrogen fixation related traits which might be valuable in breeding program in this crop.

Experiment was conducted during 1998-99 using the third generation seed mutants. M_3 seeds of mutants were surface sterilized with acidified mercuric chloride (0.2%) for 2 min. and serially filter paper, moistened with sterilized distilled water. Germinated seeds with 1-2 cm radicle were peeled under aseptic conditions and transferred to wide mouth culture tube agar slants containing MKS medium (pH 6.8) with (10 mM KNO_3) or without nitrogen. The seeds were flushed with 1 ml of exponentially growing *Rhizobium phaseoli* strain USDA 2695. Plants wee supplied with sterilized nutrient MKS medium (with or without NO_3) and grown in the growth camber at 22 ± 1°C with 10 hours light per day.

All mutants were harvested at same physiological maturity, i.e., at initial flowering stage. Root system were rinsed with tap and distilled water and nodule samples were kept on ice until enzyme extraction. Plant dry weight was recorded after drying the plants for 24 hrs at 70 °C. Total nitrogen per plant was estimated calorimetrically and nitrogenase activity as per Hardy *et al.*,. (1968).

Extraction and *in vitro* assays for root and nodule NR was estimated as described by Caba *et al.*, 1990a and nodule determined by Y-glutamyl hydrogenate semibiosynthetic assay as per Caba *et al.*, (1993).

Experiment was a randomized block design four replications. Data expressed as means for replicates was subjected to RBD ANOVA and correlation coefficients were calculated.

When plants were grown in medium without nitrate, only two mutants PDR-14-8 and PDR-14-15 showed *in vitro* root NRA (Table 1) which was assumed to represent the constitutive NR. When plants were supplied with 10 mM NO3 solution, NRA was induced in all the lines, NRA varied from

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Table 1. Nitrate reductase activity (umol NO$_2$/gFW/hr) in roots and nodules and Glutamine synthetase activity (u mol y-GH/gFw/hr) in nodules of *P. vulgaris* L. inoculated with *R. phaseoli* USDA 2695 and treated with 10 mM KNO$_3$

Mulant lines	Root NRA		Nodule NRA		Nodule GSA	
	SNO$_3$(mM)		NO$_3$(mM)		NO$_3$(mM)	
	0	10	0	10	0	10
PDR - 14-2	0	6.07	0	0.35	197	180
14-4	0	5.65	0.95	0.75	165	192
14-5	0	8.72	1-42	0.35	209	154
14-8	2.65	5.06	0.68	0.09	146	94
14-10	0	4.75	0	0	120	75
14-11	0	7.00	1.75	1.05	196	161
14-15	2.35	8.12	2.06	1.25	201	129
14-19	0	12.00	0.78	0.62	205	156
14.21	0	7.65	0	0.11	215	155
14-24	0	4.95	0	0	125	132
14-29	0	8.00	2.54	1.66	140	101
14-32	0	8.90	1.88	0.86	134	98
LSD (0.05)	0.55		0.28		14	

Table 2. Correlation matrix among parameters in *P. vulgaris* mutants inoculated with *R. phaseoli* USDA 26 and treated with 10 mM KNO$_3$

		Plant weight weight	Total N per plant	Root NR	Nodule NR	Nodule HS
Total N	10	0.812**				
Per plant	0	0.572*				
Root NR	10	-0.218	0.453			
	0	0.106	0.235			
Nodule NR	10	0.356	0.456	-0.292		
	0	0.281	0.321	-0.475		
Nodule GS	10	0.350	0.359	0.215	-0.815**	
	0	0.225	0.264	0.582*	-0.595*	
Nitrogenase	10	0.834**	0.924**	-0.721**	-0.584*	0.456
activity	0	0.725**	0.756**	-0.562*	-0.340	0.421

*Significant at 0.05 probability: ** Significant at 0.01 probability.

4.75 to 12.00 μ mol NO_2/gFW/hr.

Expression of nodular NRA differed markedly in both, response to NO_3 and dependence on plant genotype. Barring four, all mutants expressed NRA in their nodules in absence of No_3, which varied from 0.65 to 2.50 μ mol NO_2/gFW/hr.

On supplementation of NO_3 there was significant decrease in nodular NRA confirming its constitutive nature, as found in other legumes (Sawhney *et al.*, 1991 and Caba *et al.*, 1993).

All mutants expressed nodule GS activity ranging from 120 to 215 GH/gFW/hr. (Table 1) in absence of external NO_3. On supplementation of nitrate the GS activity decreased significantly in all the mutants except PDR-14-4, where there was an increase in enzyme activity. Inhibition of nodule GS by NO_3 was reported by Vezina *et al.*, (1988), stimulation of activity was reported by Sawney *et al.*, (1985).

The NRA in root and nodules and nodular GS activities were correlated with symbiotic parameters- nitrogenase activity, total correlation was observed between nitrogen metabolism activities of nodulated roots and measurement of symbiotic performance. Nitrogenase activity and nodule NRA, Nodule NR and GS were inversely correlated. From these it was concluded that there is scope of metabolic variables as potential traits of interest in breeding programs for improved nitrogen fixation in legumes.

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SELF-INCOMPATIBILITY STUDIES IN LATE GROUP CAULIFLOWER

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The present studies were conducted to identify self-incompatible strains and to observe the stability of self-incompatibility of different varieties of late group cauliflower. Ten genotypes namely PSB-1, PSB K-1, Snowball-16, KM-1, KJ-47, KJ-38, Janavon, KT-9 of late group and Pusa Himjyoti and Kathmandu Local of mid group were taken for self-incompatibility studies during 1996-97 and 1997-98, using four methods of pollination viz., natural self pollination, bud pollination, selfing of freshly opened flowers and natural cross pollination. In all the pollination methods 20-25 flowers were taken. The progeny of the seed developed by way of different types of pollination, were grown in the field next season and at the time of curd maturity five plants with overall good quality were selected. The same treatments of pollination were followed in these plants separately. In both the years, seeds per siliqua were counted at the time of seed harvesting. Measures of self-incompatibility i.e. fertility index and per cent self-incompatibility were calculated as per Gangopadhyay *et al.* (1995). Plants having F1≤1 were classified as self-incompatible and those with F1≤2 as self-incompatible. Whereas, in case of seed set per cent, less than 10 rating was considered as self-incompatible.

The mean seed count per pod or siliqua in parents and progenies in different pollination methods (Table 1) reveals that under natural self pollination, seed set per siliqua under was very low and it varied from 0.9 seeds per pod to 3.1 seeds per pod. The progenies of these genotypes, in general, also gave low seed set. Whereas all the genotypes of mid season genotypes and their progenies gave the lowest seed set comparatively under this method of pollination. When the flowers were bud pollinated, seed set irrespective of growing season of the varieties was more than natural self-pollination. Satisfactory seed set per siliqua under bud pollination in all the lines confirmed the fertility status of the pollen grains and the receptively of the stigma.

Fertility index (F_1), a measure of self-incompatibility revealed that it was less than 2 in almost all the varieties of late group while more than two in mid season varieties. As many as, 8 progenies of the late varieties also gave fertility index of more than 2 which was significantly higher the respective means of all the five progenies of the plant.

The level of self-incompatibility as

Table 1. Measures of self-incompatibility in genotypes and their strains of late group califlower

Cultivar/line/strain seed set		Progeny* self	Natural poelination	Bud poelination	Self cross	Natural index	Fertility SPO	Per cent (NSP)
		poelination	(BP)	in freshly opended	poelination	(FI)		
PSB-1 (Parent)		1.4 ± 0.25	.7± 0.39	4.4± 0.58	9.2± 0.31	2.09	47.82	15.27
	5	1.1	5.1	4.4	9.8	2.23	44.89	11.22
Mean		1.8 ± 0.26	4.4± 0.26	4.9± 0.19	9.5± 0.16	1.94± 0.07	51.57± 1.74	19.09± 02.43
PSBK-1 (Parent)		**2.3± 0.29**	**4.8± 0.44**	**6.2± 0.34**	**10.7± 0.31**	**1.73**	**57.94**	**21.49**
	2	1.7	4.7	4.5	9.8	2.42	41.28	17.34
	3	1.8	4.4	5.3	10.8	2.04	49.07	16.67
Mean		1.9± 0.16	4.7± 0.15	5.6± 0.39	9.5± 0.38	1.77± 00.16	55.23± 4.49	19.02± 01.60
KJ-38 (Parent)		**22± 0.69**	**4.9± 0.41**	**6.4± 0.28**	**9.2± 0.18**	**1.44**	**69.56**	**23.91**
	3	1.2	4.7	3.3	9.3	2.81	35.48	12.90
	5	1.0	4.6	3.6	9.8	2.88	36.73	10.20
Mean		1.8± 0.29	4.1± 0.25	4.9± 0.58	9.6± 0.16	2.13± 0.26	51.21± 0.26	18.87± 3.18
KM-47 (Parent)		**1.8± 0.23**	**4.7± 0.49**	**6.5± 0.47**	**10.3± 0.20**	**1.58**	**63.10**	**17.47**
	2	0.7	4.8	4.4	10.9	2.47	40.36	6.42
	4	0.8	5.5	4.8	10.7	2.22	44.85	7.47
Mean		1.3± 02.20	4.9± 0.26	5.9± 0.49	10.4± 0.18	1.84± 0.19	57.08± 5.44	12.57± 2.12
KM-1 (Parent)		**3.1± 0.29**	**4.6± 0.45**	**6.6± .58**	**9.4± 0.2**	**1.42**	**70.21**	**32.97**
	1	1.5	2.8	3.0	9.4	3.13	31.91	15.95
Mean		2.5± 0.28	4.4± 0.43	4.8± 0.43	9.1± 0.19	1.99± 0.25	52.00± 05.07	27.41± 3.11
Snowball-16(Parent)		1.6± 0.2	4.1± 0.4	5.1± 0.53	9.4± 0.28	1.84	54.25	17.02
	2	1.2	4.5	4.4	10.2	2.31	43.14	11.76
	3	1.8	5.3	5.1	10.8	2.11	47.22	16.67
	5	0.9	5.8	4.9	11.0	2.24	44.54	8.18
Mean		1.38± 0.13	4.6± 0.37	5.22± 0.25	10.56± 0.17	2.04± 0.10	49.50± 02.59	13.08± 01.30
Janavon (Parent)		1.8± 0.25	51± 0.43	7.5± 0.4	10.6± 0.32	1.42	70.75	16.98
	2	1.5	4.8	4.1	9.1	2.21	45.05	16.48
Mean		1.7± 0.07	4.8± 00.25	5.3± 0.27	10.2± 0.26	1.94± 0.06	51.57± 1.52	16.98± 0.61
KT-9 (Parent)		**1.4± 0.25**	**4.8± 0.67**	**5.7± 0.61**	**9.6± 0.2**	**1.68**	**59.37**	**14.58**
	2	1.3	4.9	4.2	9.8	2.33	42.85	13.26
	4	0.8	5.2	4.3	10.8	2.51	39.81	7.40
Mean		1.4± 0.23	4.5± 0.30	4.5± 0.31	9.2± 0.54	2.06± 0.13	49.35± 3.27	16.04± 2.64

Contd

Kathmandu Local			**0.9± 0.28**	**5.2± 0.39**	**4.6± 0.25**	**11.5± 0.32**	**2.50**	**40.00**	**7.82**
(Parent)		1	0.8	5.0	4.0	10.7	2.67	37.38	8.24

Table 1. Contd..

2	0.7	5.0	5.2	11.8	2.26	44.06	5.93		
		3	1.0	5.1	5.5	12.6	2.29	43.65	7.93
		4	0.8	5.8	5.0	11.9	2.38	42.01	6.72
		5	1.2	5.2	5.1	11.1	2.17	45.94	10.81
	Mean		0.9± 0.08	5.2± 0.13	4.9± 0.22	11.6± 0.29	2.35± 0.07	42.61± 1.29	7.92± 0.74
Pusa Himjoti			1.1± 0.29	5.6± 0.042	4.4± 0.33	10.7± 0.23	2.43	41.12	10.28
(Parent)		1	0.7	5.2	4.6	10.8	2.34	42.59	6.48
		2	0.6	5.0	4.1	11.4	2.78	35.96	5.26
		3	0.5	5.4	3.8	9.6	2.52	30.50	6.77
		4	0.8	5.3	3.6	11.8	3.27	30.50	6.77
		5	0.4	5.0	3.8	10.9	2.86	34.86	3.67
Parents SE± =			± 0.14	± 0.16	± 0.32	± 0.24			
Progenies SE± =			± 0.30	± 0.98	± 0.30	± 0.31			

* values of only those progenies which gave significant results.

expressed in per cent seed set (Table 1), revealed that in late group varieties per cent seed set under natural self-pollination was more than 10 per cent. KM-1, KJ-38 and PSBK-1 gave per cent seed set of 32.97, 23.91 and 21.49 respectively, while in others it ranged from14.50 (KT-9) to 17.47 (KJ-47). Similarly, the per cent seed set based on selfing of freshely opened flowers was more than 50 per cent in all the genotypes except PSB-1 where it was 47.82 per cent. In the progenies of late group, the per cent seed set as low as 6.42 per cent (2 of KJ-47, 7.47 per cent (4 of KJ-47), 8.18 per cent (5 of Snowball-16) and 7.40 per cent (4 of KT-9). In all these progenies seed set based on selfing of freshely opened flowers was less than 50 per cent while under natural cross pollination it was very high in these progenies. These progenies also gave fertility index of 2 or more indicating the presence of self-incompatibility in late group cauliflower. Comparison of seed set under self-pollination and natural cross pollination methods in the progenies reveals a significant difference. Bagging of the flowers resulted in low or negligible seed set which says for self-incompatible nature of these selected plants. But the seed set, under bud pollination and self pollination of freshly opened flower, increased and the two treatments were at par with each other. This at least confirmed the pollen fertility and proper receptivity of the stigma and hence self-compatibility, but very high seed set under natural cross pollination method reveals that foreign pollen was more effectively germinating on the stigma and hence forming more seed as compared to other methods of pollination. This\show that these varieties have self-incompatibility but of low magnitude which resulted in out crossing

Compatability studies revealed presence of self-incompatibility of low magnitude in late group varieties and their progenies which offers opportunities for further selection, stabilization an thus utilization of self-incompatibility in late group. Involvement of more genotypes of late group in such kind of studies followed by further selection for self incompatibility may result in development of a self incompatible variety in late group.

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EFFECT OF DIFFERENT SPACINGS ON GROWTH AND YIELD OF CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA LINN.*)

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A field experiment was conducted at Horticulture Farm of S.K.N. College of Agriculture, Jobner during winter (rabi) season of 1997-98, which is situated at 26.5° north latitude and 75.28° east longitude and elevation of 427 meters above mean sea level at Jaipur district of Rajasthan. Average rainfall is 500 mm, most of which has been received during July to mid September. Water of this area is saline in nature, falls in class C_4S_4. The pH of water was found to be 7.7, EC 3.05 m mhos/cm at 25°C and sodium content was 25.0 meg/litre. The soil type was sandy loam with pH 8.5, EC 0.29 mm hos/cm at 25°C, soluble cations 9.00 meg/litre, potassium 0.42 and Calcium + magnesium were 5.00 and soluble anions (meg/litre) were carbonate (0.50), bicarbonate (3.50) and chloride (8.50). The experiment was laid out in a randomized block design with four replications and three levels of spacing, S1 (30 x 45 cm), S2 (45x45) and S_3 (60 x 45 cm) were maintained. Four nursery beds of 2 x 1 m size were prepared and 10 g seeds per bed were sown in rows.

The seedlings were ready for transplanting in six weeks at 4.5 cm height. The distance row to row was kept 45 cm and plant to plant was 30 cm, 45 cm and 60 cm according to three levels of spacing. The number of plants according to three levels of spacing was S_1 (72 plants), S_2 (48 plants) and S_3 (36 plants) on plot size of 9.72 m^2. All other cultural practices like irrigation, fertilization, interculture operations, plant protection measures etc. were done timely as per recommendation to grow a normal crop. Ten plants were randomly selected in each plot and tagged for recording observations.

The data presented in Table 1 revealed that the plant height was not affected significantly with the increasing levels of spacing at all stages of crop growth However, the farthest spacing S_3 (60 x 45 cm) resulted in maximum plant height. Number of leaves per plant significantly increased with increasing levels of spacing at 30 DAT and 60 DAT. The per cent increase in number of leaves per plant were 8.33 in treatment S_3 over S_1 at 30 DAT. At 60 DAT, the per cent increase in number of leaves was 9.98 in treatment S_3 recording maximum number of leaves (13.99) over S_1.Stem diameter (cm) was significantly increased with the increasing levels of spacing viz., S_1, S_2 and S_3. The highest diameter of 1.28 cm was recorded with the spacing of S_3(60x45cm) whereas at S2 (45x45 cm) and S_1 (30x45 cm) spacing recorded 1.15 and 1.00 cm, respectively (Table 1). Maximum leaf area (315.41 cm^2) was recorded at S3 (60 x 45 cm) while minimum (310.83 cm^2) at the spacing of S_1 (30 x 45 cm) at harvest. The investigation showed that increasing levels of spacing significantly increased the number of leaves per plant at 30 DAT and 60 DAT and stem diameter at harvest. This may be due to more area available for the plants at widest spacing receiving more light and lesser competition for nutrients due to less number of plants accommodated at widest spacing (S_3). The present results are in agreement with Strandberg (1985), Singh and Neopaney (1993).

The data pertaining in Table 1 showed that the S_3 spacing (60 x 45 cm) significantly increased the head weight (g) over the treatment S_1 (30 x 45 cm) while S_3 and S_2; S_2 and S_1 were statistically at par to each other. The maximum average head weight (831.25 g) recorded under the spacing S_3, while the minimum (766.33g) was observed at the spacing S_1. The per cent increase in head weight was 8.47 per cent under S_3 over S_1. There was significant increase in biological and economical yield with closest spacing S_1 over the widest spacing S_3. However, significant difference could not be recorded between S_3 and S_2; S_2 and S_1. Maximum per cent harvest index (71.25) was obtained under S_1 while minimum was at S3 (70.29). The increasing levels of spacing significantly increased the average head weight, whereas closer spacing resulted in higher biologicals and economic yield. Prabhakar and Srivivas (1987) that head yield significantly increased with increasing plant density as well as the maximum yield was obtained at closest spacing. Similar findings were also reported by Mullins and Straw (1990) in broccoli, Patil *et al.*, (1995) in cauliflower.

Table 1. Effect of different spacing (s) on plant height (cm), number of leaves per plant, stem diameter (cm), leaf area (cm^2), head weight (g), biological (q ha^{-1}), economic yield (q ha-1) and harvest index (%)

Spacing	Plant height			No. of leaves per plant			Stem diameter		Leaf area		Head weight	Biolo-yield	Eco-yield	Harvest
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	45 DAT	At harvest	45 DAT	At harvest				
S_1 (30x45 cm)	9.10	13.43	18.41	6.48	12.72	16.88	0.605	1000	277.16	310.81	766.33	399.08	282.91	71.25
S_2 (45x45 cm)	9.23	13.44	18.79	7.01	13.48	17.16	0.616	1.141	282.58	310.84	790.83	389.22	271.77	70.76
S_3 (60x45 cm)	9.27	14.70	19.66	7.02	13.99	17.88	0.630	1.280	284.16	315.41	831.25	374.01	263.19	70.S
S.EM±	0.126	0.490	0.510	0.091	0.108	0.360	0.013	0.026	2.96	3.28	77.91	5.94	4.13	0.52
C.D. 5%	NS	NS	NS	0.265	0.314	NS	NS	0.77	NS	NS	52.13	17.20	12.03	NS

NS = Non-significant.
DAT = Days after transplanting

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EFFECT OF NITROGEN AND SULPHUR ON QUALITY AND NUTRIENT CONTENT OF FODDER PEARLMILLET [*PENNISETUM GLAUCUM* (L.) R.Br. EMEND STUNTZ]

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The efficiency of milch as well as drought animals largely depends upon the supply of quantity of fodder in which green fodder plays a vital role. In Rajasthan prevalence of high temperature, dry hot winds coupled with light texture of soil restrict the choice of a green fodder crop during summer, Pearlmillet is the best choice whose merits have been described by light textured soils of Rajasthan. It is a constituent of the chloroplast. Nitrogen is vitally associated with activity of each living cell. Sulphur has been considered as fourth essential major plant nutrient. It plays an important role in protein and chlorophyll synthesis as well as for the functioning of several enzyme systems. Keeping these considerations in view, the present field investigation was undertaken.

A field experiment was conducted during summer, 2001 at Agronomy Farm S.K.N. College of Agriculture, Jobner. The treatments, comprising four levels of nitrogen (60, 90, 120 and 150 kg ha^{-1}) and four levels of sulphur (0, 20, 40 and 60 kg ha^{-1}), making 16 combinations were replicated 4 times in randomized block design. The soil was loamy sand, low in available nitrogen (130.5 kg ha^{-1}) medium in P_2O_5 (17.72 kg ha^{-1}), K_2O_5 (150.90 kg ha^{-1}) and low in sulphur (0.0012%), with pH 8.10 (1:2 soil water suspension). A uniform dose of 40 kg P^2O^5 ha^{-1} through DAP was drilled in soil before sowing. Nitrogen as per treatments was applied through DAP and urea in three equal splits. One third nitrogen was applied as basal, one third at 30 DAS and remaining one third after first cutting. Sulphur as per treatment was applied through gypsum (13%S) and thoroughly incorporated in the soil before sowing. Fodder pearlmillet variety, Raj bajra Chari-2 was sown on 12th April, 2001, 30 cm apart.

Results indicated that application of 120 kg N ha^{-1}, increased the crude protein and crude fibre content in fodder significantly at both the cutting as compared to 60 and 90 kg N ha^{-1}. Whereas ether extract content increased only upto 90 kg N ha^{-1}. But nitrogen extract content and nutritive ratio decreased significantly upto 90 kg N ha^{-1} over 60 kg N ha^{-1} at both the cutting (Table 1). The significant increase in crude protein, crude fibre and ether extract content in fodder is might be due to increased N content in fodder as nitrogen is an integral part of protein. Application of nitrogen significantly decreased the NFE content could be attributed to the fact that N application had significantly effect on crude protein content there by reducing the proportion of carbohydrates and hence decrease NFE content. The similar findings

Table 1. Effect of nitrogen and sulphur on quality parameters of fodder pearlmillet

Treatments	Crude protein (%)		Crude fibre(%)		Ether extract (%)		NFE(%)		Nutritive ratio	
	I cutting	II cuting	I cutting	II cuting	I cutting	II cuting	I cutting	II cuting	I cutting	II cuting
Nitrogen (kg/ha^{-1})										
60	9.91	6.78	27.04	28.49	2.11	1.93	49.69	52.47	8.46	13.94
90	11.71	7.90	28.43	29.93	2.21	2.03	46.01	49.62	7.91	13.08
120	12.39	8.48	29.65	31.14	2.26	2.07	43.95	47.67	7.70	12.76
150	12.64	8.64	29.92	31.54	2.28	2.09	13.36	47.04	7.62	12.69
C.D. at 5%	0.38	0.29	1.19	1.09	0.08	0.07	1.96	2.08	0.46	0.73
Sulphur (kg/ha^{-1})										
0	10.26	7.03	27.51	28.87	2.13	1.94	18.80	51.80	8.13	13.86
20	11.84	7.93	28.86	30.08	2.21	2.02	45.46	49.44	7.89	13.04
40	12.26	8.31	29.22	30.99	2.25	2.07	44.55	48.00	7.72	12.82
60	12.30	8.52	29.45	31.16	2.26	2.08	44.20	47.56	7.65	12.75
C.D. at 5%	0.38	0.29	1.19	1.09	0.08	0.07	1.96	2.08	0.46	0.73

were also reported by Munda *e t al.* (1983).

Increasing levels of nitrogen upto 120 kg ha^{-1} increased the nitrogen content of fodder at both the cutting as well as total nitrogen and sulphur uptake significantly. But sulphur content of fodder at both the cuttings remained unaffected due to application of graded levels of nitrogen (Table 2). However, the total nitrogen and sulphur uptake increased significantly due to application of 120 kg N ha^{-1}, registering an increase of 67.39 and 40.84 per cent over 60 kg N ha^{-1}, 16.09 and 11.51 per cent over 90 kg N ha^{-1}, respectively.

The significant increase with increasing levels of nitrogen at both the cutting as well as total N and S uptake by fodder might be due to the fact that increased availability of nitrogen of plants resulted in vigorous vegetative as well as profuse root growth, leading to improved absorption of other nutrients also from soil and hence, more fodder yield. The results obtained here are in close conformity with those of Singh *et al.* (1983).

Application of 20 kg S ha^{-1} significantly increased the crude fibre and ether extract content at both the cuttings however, further increasing in level of sulphur did not increase significantly. While crude protein content increased up to 40 kg S ha^{-1} over control and 20 kg S ha^{-1}. Whereas, nitrogen free extract content and nutritive ration decreased significantly with application of 20 kg S ha^{-1} over control (Table 1). The higher availability of N to the plants due to S addition is a reflection on the increase in the production of crude protein, ether extract and crude fibre. The similar findings were also reported by Kaushik *et al.* (1996). Nitrogen and sulphur

Table 2. Effect of nitrogen and sulphur on nutrient content and uptake by of fodder pearlmillet

Treatments	N-content (%)		N-uptake	S-content(%)		S-uptake
	I cutting	II cuting	(kg h^{-1})	I cutting	II cuting	(kg ha^{-1})
Nitrogen (kg ha^{-1})						
60	1.585	1.086	72.74	0.161	0.120	7.669
90	1.879	1.264	104.88	0.164	0.125	9.686
120	1.983	1.357	121.76	0.166	0.129	10.801
150	2.025	1.383	127.86	0.167	0.130	11.178
CD at 5%	0.074	0.057	8.46	NS	NS	0.692
Sulphur (kg ha^{-1})						
0	1.643	1.12	78.45	0.155	0.116	7.724
20	1.894	1.29	104.58	0.163	0.125	9.339
40	1.962	1.331	119.46	0.169	0.130	10.898
60	1.973	1.364	124.75	0.170	0.133	11.373
CD at 5%	0.074	0.057	8.46	0.009	0.011	0.692

content in both the cuttings significantly increased levels of sulphur upto 40 kg ha^{-1} increased the total nitrogen and sulphur uptake significantly over control and 20 kg S ha^{-1} however, further increase in dose of sulphur over 40 kg S ha^{-1} could not bring significant improvement (Table-2). Significnat increase in nitrogen and sulphur content as well as total nitrogen and sulphur uptake due to sulphur fertilization is might be due to the better renaturation environment in the *rhizosphere* as well as in the plant system by increasing the availability of nutrients in the root zone. Similar results were reported by Singh and Singh (1987).

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EFFECT OF INOCULATION AND LEVELS OF NITROGEN ON GROWTH AND YIELD OF BARLEY *(HORDEUM VULGARE* L.)

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Barley is considered as an important food grain among poors. It is generally grown on marginal and sub-marginal lands with low inputs. Of the various agronomic practices, judicious and balanced fertilization is considered most important for securing higher yields. Thus the major constraint limiting barley production is fertility status of soil coupled with inadequate nutrition. In view of declining poor productivity of barley in Rajashan, fertilizing it with suitable doses of nitrogen along with seed inoculation with biofertilizers offers a good scope to enhance production potential of barley. Barley has higher yield potential and responds favourably to nitrogen (Singh *et al.* 1980) and biofertilizers (Tiwari *et al.* 1989). Hence the present experiment was conducted to evaluate the response of barley to nitrogen and biofertilizers.

A field experiment was conducted in *rabi* of season 1999-2000 at the S.K.N College of Agriculture, Jobner. The soil was loamy sand in texture with pH 8.2, organic carbon 0.24% and available N 140.50 kg ha^{-1}. Barley cv. RD 2052 was sown on November 20 in row 25 cm apart. The treatments consisted of 5 levels of N (0, 25, 50, 75 and 100 kg ha^{-1}) and 4 biofertilizers (control, *Azotobacter, Azospirillum* and *Azotobacter + Azospirillum)* replicated thrice in randomized block design. A uniform dose of 30 kg P_2O_5 ha^{-1} was applied through single superphosphate as basal at sowing. Nitrogen was applied through urea as per treatments in 3 splits (halt at sowing, on-fourth at first irrigation and remaining one-fourth at second irrigation). The seeds were inoculated with the career based culture of *Azotobacter Chroococcum, Azospirillum brasilense* individually and also in combinations as per treatments before sowing.

Increasing levels of N up to75 kg ha^{-1} improved all the growth and yield attributes significantly but remained at par with that of 100 kg N ha^{-1} (Table 1). Nitrogen fertilization increased grain and straw yields markedly up to 75 kg N ha^{-1}, the increase being 18.3, 8.9 and 2.9 q ha^{-1} over 0, 25 and 50 kg N ha^{-1}, respectively. The highest level of 100 kg N ha^{-1} had no advantage over 75 kg N ha^{-1}. Similar increase in grain and straw yields of barley was also observed by Awasthi ans Surajbhan (1983).

Seed inoculation through biofertilizers significantly encouraged the growth and yield attributed over no inoculation. The enhancement in plant growth with inoculation was due to synthesis of biologically active substances like vitamins, auxins and gibberellins etc. Seed inoculation with *Azotobacter + Azospirillum* recorded the maximum growth parameters over control and individual inoculation of *Azotobacter* and *Azospirillum.*

Table 1. Effect of different levels of nitrogen and seed inoculation growth, yield attributes and yield of barley

Treatment	Plant height (cm)	Tillers m^{-1} row	Dry matter accumulation m^{-1} row (g)	Effective filters m^{-1} row	Ear length (cm)	Grains ear^{-1}	1000-grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Nitrogen levels (kg ha^{-1})									
0	80.3	60.3	214.6	52.6	5.12	38.6	43.1	30.17	38.76
25	84.4	64.8	236.4	59.8	6.14	40.9	44.5	39.53	47.34
50	88.2	69.5	248.8	64.7	6.69	42.8	45.9	45.55	53.94
75	91.1	73.9	260.3	68.3	7.74	44.6	47.2	48.43	59.21
100	92.4	74.3	265.2	70.5	7.86	44.9	47.5	49.62	60.28
C.D. (P=0.05)	2.31	3.06	8.63	2.82	0.32	1.42	1.23	2.67	3.59
Biofertilizers									
Control	84.2	63.4	231.8	57.3	5.58	40.2	43.3	36.13	44.38
Azotobacter	87.6	69.5	248.6	64.6	6.93	42.9	46.1	44.34	53.32
Azospirillum	86.9	67.8	244.0	63.4	6.72	42.1	45.6	42.78	51.69
Azotobacter + *Azospirillum*	90.4	73.5	255.8	67.4	7.83	44.3	47.6	47.9	58.23
C.D. (P=0.05)	2.07	2.74	7.72	2.52	0.28	1.27	1.09	2.38	3.21

Seed inoculation with *Azotobacter* + *Azospirillum* gave significantly higher grain and straw yields. The grain yield increased by 31.2, 6.9 and 10.8%, respectively over control, *Azotobacter* and *Azospirillum* inoculation. Similarly, seed inoculation with *Azotobacter* and *Azospirillum* individually being at par resulted in significant improvement in grain and straw yields over no inoculation (Table 1). The relative perforamens of these inoculants was in the order: *Azotobacter* + *Azospirillum*> *Azotobacter* > *Azospirillum*. Thus dual inoculation of *Azotobacter and Azospirillum* has great of enhancing the productivity. It confirms the observations of Negi *et al.* (1987) and Tiwari *et al.* (1989).

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CORRELATION AND PATH COEFFICIENT ANALYSIS IN TOMATO (*LYCOPERSICON ESCULENTUM MILL.)*

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Thirty diverse genotypes of tomato were sown in randomized block design with three replications at the experimental farm of the Department of Vegetable crops, Dr. Y.S. Parmar University of Horticulture and forestry, Solan during April 1999 to September 1999. Plants of each genotype were planted in a plot of 2.7x1.8 m at a spacing of 90x30 cm. Ten randomly selected competitive plants from each plots were tagged to record various growth and yield parameters. The data collected were subjected to statistical analysis as per standard procedures.

The correlation coefficients are presented in Table 1. Correlation coefficients at genotypic level were generally higher in magnitude than the corresponding phenotypic ones. Results indicated that yield per plant was positively and significantly associated with plant height, number of fruits per plant, fruit shape index and pericarp thickens. Hence effective improvement in tomato yield through these components could be achieved by resorting to simple selection. Raijadhav *et al.* (1997) also reported significant positive correlation of number of fruits per plant with yield . Bhutani and Kalloo (1989) reported similar association of pericarp thickness with yield while Mishra and Mishra (1989) reported significant positive correlation of plant height with yield.

The results of the path coefficient analysis are presented in Table 2. Path coefficient analysis indicated that number of fruits per plant had maximum positive direct effect on yield per plant followed average fruit weight. Thereby indicating a true correlation. Hence these two characters can be taken as the major components for the improvement of yield. Maximum positive direct effect of number of fruits per plant on yield have also been reported by Bhutani and Kalloo (1989).

The results obtained from correlation studies are also confirmed by the path coefficient analysis, which indicates that selection should be based on more number of fruits with higher average fruit weight. The traits other than those studied had only a minor role towards the improvement of yield potential, as the value of residual effect (0.1622) is low.

Table 1. Phenotypic (r p) and genotypic (r g) correlation coefficient among various traits in tomato

Characters		2	3	4	5	6	7	8	9	10	11
1. Days to marketable	rp	0.171	-0.227	0.035	-0.010	0.162	0.357	-0.-84	-0.061	0.240	-0.003
picking	rg	0.220	-0.246	0.125	-0.014	0.192	0.450	-0.105	-0.088	0.286	-0.027
2. Plant height (cm)	rp		0.337	0.435*	0.320	-0.123	0.623**	-0.407**	-0.407*	-0.026	0.039
	rg		0.369	0.632	0.349	-0.131	0.696	0.697	-0.475	-0.338	0.092
3. Number of fruits per	rp			0.453*	0.656*	-0.762**	0.024	0.589**	-0.505**	-0.803**	0.200
plant	rg			0.631	0.728	-0.811	0.028	0.598	-0.614	-0.834	0.275
4. Number of fruits per	rp				0.403	-0.401*	0.416*	0.308	-0.425	-0.347	0.193
cluster	rg				0.666	-0.571	0.599	0.488	-0.763	-0.470	0.365
6. Size of stem and scar	rp					-0.612**	0.243	0.416	-0.636**	-0.475	0.319
	rg					-0.651	0.287	0.52	-0.768	-0.514	0.502
7. Pericarp thickness	rp						0.050	-0.215	0.578**	0.785**	-0.338
(mm)	rg						0.051	-0.259	0.672	0.818	-0.434
8. Yield per plant (g)	rp							0.412*	-0.345	0.25	0.107
	rg							0.453	-0.515	0.242	0.203
9. No. of locules pe	rp								-0.312	-0.137	0.060
fruits	rg								-0.428	-0.149	0.101
10. Average fruits weight (g)	rp									0.416*	-0.363
	rg									0.505	-0.593
11. Total souble solids (oB)	rp										-0.219
											-0.322

**, * Significant at 5% and 1% level of significance, respectively.

Table 2. Estimates of direct and indirect effects and genotypic correlation oefficients between yield per plant and various traits

Characters	1	2	3	4	5	6	7	8	9	10	rg
1. Days of marketable picking	**-0.137**	0.057	-0.340	-0.018	0.001	0.039	0.056	0.006	0.232	-0.002	-0.105
2. Plant height (cm)	-0.030	**0.260**	0.510	-0.089	-0.022	-0.027	0.086	0.035	-0.031	0.005	0.679
3. Number of fruits per plant	0.034	0.096	**1.381**	-0.089	-0.046	-0.165	0.003	0.045	-0.676	0.016	0.598
4. Number of fruits per cluster	-0.017	0.165	0.872	**-0.141**	-0.042	-0.116	0.074	0.056	-0.382	0.021	0.488
5. Fruit shape index	0.002	0.091	1.006	-0.094	**-0.064**	-0.133	0.035	0.056	-0.417	0.029	0.512
6. Size of stem and scar (mm)	-0.026	-0.034	-1.120	0.081	0.042	**0.204**	0.006	-0.049	0.664	-0.025	-0.259
7. Pericarp thickness (mm)	-0.062	0.181	0.039	-0.085	-0.018	0.010	**0.123**	0.038	0.196	0.012	0.435
8. No. of locules per fruit	0.012	-0.124	-0.848	0.108	0.049	0.137	-0.064	**-0.073**	0.410	-0.034	-0.428
9. Average fruit weight (g)	-0.039	-0.010	-1.152	0.006	0.033	0.167	0.030	-0.037	**0.811**	-0.019	-0.149
10. Total soluble soilds (°B)	0.004	0.024	0.38C	-0.051	-0.032	-0.088	0.025	0.044	-0.261	**0.058**	0.101

Residual effect = 0.1622

Underlined values indicate direct effects

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EFFECT OF STAND GEOMETRY AND DENSITY MANAGEMENT ON THE GROWTH AND YIELD OF SHATAVAR *(ASPARAGUS RECEMOSUS WILLD.)*

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Shatavar (*Asparagus recemous* Willd) is one of the most principle medicinal plants in the tropical and sub-tropical regions. It is a scandent climber,. It is know to have several medicinal properties. The roots are bitter, sweet oleaginous, cooling, indigestible, appetizer, alliterative stomachache tonic, aphrodisiac, galactagogue, and astringent to the bowels. Roots are being used as a remedy for tuberculosis, leprosy, epilepsy, dysentery, tumors, inflammations and night blindness. Spacing and planting system are an essential input for a successful crop production among the planting system ridge and furrow has a special position as evidence its robe in increasing the tuber yield.

The field experiment was conducted during the 2000 to 2001 at NBPGR experimental station, Issapur, New Delhi, in factorial randomized block design with 12 treatments replicated 3 times. The soil was sandy loam, alkaline (pH 7.8 to 8.2), low in organic carbon (0.2-0.3%), available phosphorus (15 kg P_2O_5/ha) and potassium (350-800 Kg K_2O_5/ha.) The recommended row spacing (90,120,150 cm) & plant spacing (60, 90, 120, 150 cm) with two ridge & furrow and flat planting system were used in the experiment. The other agronomical condition is normal. The average total rainfall received annually 400 mm. The crop seasons were quite normal for crop growth. Major portion of rainfall (350 mm) was received during the July to September.

There was significant difference in plant height between tow planting system (Table 1) and maximum plant height was recorded under ridge & furrow planting system (109.84 cm) than flat planting system. With regard to the spacing combination viz. 45x15cm spacing promoted significantly plant height (117.42 cm) as compared to other spacing combination (Table 2). The effect of interaction was found to be significant variation (Table 3) in plant height was recorded under treatment combination ridge & furrow planting system with 45x15 cm spacing. The Uncini & Ferrari (1998) and Tewari & Misra (1996) also agree to the present observation.

Significant variation in the number of branches per plant between two planting system (Table 1) and highest number of branches per plant was recorded under ridge & furrow planting system (7.10) than flat planting system (6.33). The maximum number of branches per plant (7.79) was observed with 45 x 15 am spacing combination (Table 2) while lowest number of branches per plant (5.78) was associated with 60 x 30 cm. The highest number of

Table 1. Effect of planting system and spacing on growth and yield of satavar (*Asparagus recemosus* Willd)

Treatment	Plant height (cm)	No. of branches per plant	Plant spread (cm^2)	Root yield tones/ha
Planting System				
Ridge & Furrow	109.84	7.1	153.44	12.86
Flat	109.19	6.33	146.7	11.04
CD at 5%	0.601	0.30	5.044	3.779
Spacing				
30x 15	105.13	6.48	145.9	15.63
30x30	109.99	7.00	155.38	11.41
45x15	117.42	7.79	168.56	14.76
45x30	110.86	6.91	152.76	11.56
60x15	107.26	6.31	143.84	12.12
60x30	106.41	5.78	133.97	6.23
C.D. at 5%	1.041	0.519	8.737	9.702

Table 2. Effect of planting system and spacing of shataver

Treatment	Plant height (cm)	No. of branches per plant	Plant spread (mc^2)	Root yield tones/ha
Ridge & Furrow				
30x15	103.43	7.08	141.2	16.61
30x30	109.42	7.65	156.38	12.35
45x45	119.28	8.38	176.45	16.52
45x30	112.03	6.84	154.64	12.98
60x15	108.08	6.74	150.84	11.89
60x30	106.79	5.88	141.11	6.84
Flat system				
30x15	106.84	5.87	150.6	14.65
30x30	110.56	6.35	154.38	10.47
45x15	115.56	7.21	160.67	13.01
45x30	109.69	6.98	150.88	10.15
60x15	106.44	5.87	136.83	12.36
60x30	106.02	5.67	126.82	5.61
C.D. at 5%	1.473	0.734	12.356	2.87

branches per plant was noted under treatment combination (Table 3), Ridge & furrow planting system with 45x15 cm spacing and lowest number of branches per plant was found in flat planting system with 60 x 30 cm. In conformity with the present finding increase in average number in branches per plant due to spacing was also observed by Tewari & Misra (1996).

The maximum plant spread was recorded under (Table 1), ridge & furrow planting system (153.4 cm^2) than flat planting system (168.56 cm^2). The maximum plant spread (133.97 cm^2) was associated (Table 2) with 60x30 cm spacing combination. Maximum plant spread (176.45 cm^2) noted under treatment combination (Table 3) ridge & furrow planting system with 45x15cm spacing and minimum (126. 82 cm^2) plant spread was found in flat planting system with 60 x 30 cm spacing. Similar finding that more plant spread with spacing has been reported by Kaufmann & Orth (1989).

The higher tuber yield per hectare was noted under ridge & furrow planting system (12.86 t/ha) than flat planting system (11.04 t/ha). The highest tuber yield per hectare 915.63 t/ha) was found under 30 x 15 cm spacing combination than (14.76 t/ ha) 45 x 15 cm spacing combination and lowest tuber yield per hectare was observed in 60 x 30 cm spacing combination. The highest tuber yield per hectare of (16.52 t/ ha) was noted under treatment combination ridge & furrow planting system with 30 x 15 cm spacing. A number of previous worker Uncini & Ferrari (1988), Tewari & Misra (1996) and Loughton & Baker (1984) have been reported the same finding.

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PHENOTYPIC STABILITY IN BREAD WHEAT (*TRITICUM AESTIVUM* L.) UNDER NORMAL AND SALINE ENVIRONMENTS

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Salinity remains man's one of oldest environmental problem (Downton, 1985). A large part of wheat cultivation is partly or wholly affected by salt stress. In order to formulate a comprehensive breeding and selection strategy for salt affected areas, the main objective is to identify salt tolerant genotypes. The study of genotype x environment interactions is important not only from genetical and evolutionary point of view but is also related to agricultural production problem (Breese, 1969). An attempt was, therefore made to study the phenotypic stability of yield and its components by using 19 parents and 60 crosses of bread wheat under four different normal and saline environments.

Nineteen genotypes of bread wheat consisting of 15 lines and 4 testers were crossed in line x tester fashion. The resultant 60 crosses along with their 19 parents were grown during *rabi* 1998 - 99 in randomized block design with three replications in four different environments at Research Farm, S.K.N. College of Agriculture, Jobner under normal (E1 with 1.54 Ece and 7.60 pH) and saline (E2 with 9.94 Ece and 8.46 pH) conditions and at Agricultural Farm, Asalpur under normal (E3 with 1.50 ECe and 7.58 pH) and saline (E4 with 8.01 Ece and 9.10 pH). Each plot comprised of single row of two meter length. Row to row and plant to plant distance were kept 30 cm and 10cm, respectively. Observations were recorded on five randomly selected competitive plants from each replication and environment for all the parents and F_1s for 12 characters. The components of genotype x environment interaction were estimated according to Eberhart and Russell (1966) model.

The stability analysis (Table 1) revealed that mean squares due to genotypes, environment and g x e interactions were highly significant for all the characters studied indicating the presence of variability among genotypes, environments and differential response of genotypes to different environments. The genotypes x environment linear component was significant for number of effective tillers/ plant, number of grains/spike, grain weight/ spike, biological yield/plant, harvest index and grain yield/plant indicating the performance with respect to yield and its components was predictable. The variance due to pooled deviation (non-linear) was highly significant for all the characters, which suggested that genotypes differed considerably with respect to their stability. Menon and Sharma (1997) and Shekhawat *et al.* (1999) reported significance of linear and non-linear components of g x e interactions.

Joint consideration of stability parameters revealed that out of 19 parents only one parent UP 2338 showed high mean value with unit regression and non-significant S^2di. Hence this parent can be recommended for cultivation under varied normal and saline environment conditions and may be utilized in hybridization programme. Out of 60 crosses, 34 crosses possessed more grain yield but only four crosses viz., Raj3777 x Raj3077, Sonlika x Kh65, WH157x KRL 1-4 and Job983 x Lok1 exhibited higher grain yield with around unity regression and non-significant deviation from regression. This showed that these crosses were stable in different normal and saline environments. On the other hand the parent Raj 3777 and crosses HD2285 x Raj3077, HD2285 x Lok1, UP2338 x KRL 1-4, Job79 x Kh65, Job673 x Raj3077, Raj1482 x Kh65, Raj3777 x Kh65, WH157 x Lok1, Job 666 x Kh 65 and UP2338 x Raj3077 were stable under normal environments for grain yield and yield attributing characters as these had high mean values, unit regression coefficient and non-significant S^2di. Similarly, the genotypes having higher mean values along with unit regression and non-significant S^2 di suited for saline environments for grain yield and related traits were JOb79, KRL 1-4, Raj3077, Job2028 x Kh65, Raj 1482 x KR1-4, Job673 x Lok 1, Raj3777 x KRL1-4, JOb 151 x KH65, Job 245x Lok1, Job983 x Kh65 and HP 1529 x Kh65. Therefore, these can be advanced for isolating stable and desirable segregates.

Since *per se* performance and stability are also independent traits and were controlled by different sets of gene systems it was expected that the stability of F_1s may be influenced by stes of genes present in

Table 1. Mean square for phenotypic stability of 12 characters in bread wheat

Source of variation	d.f.	Days to heading	Days to maturity	Plant height	Number of effetive tillers per plant	Spike length	Number of spikelets per spike	Number of grains per spike	Grain weight per spike	100-grain weight	Biological yield per yield per	Harvest index	Grain yield per plant
Genotypes (G)	78	48.901**	30.58**	169.519**	2.580**	0.88**	58.269**	0.161**	35.913**	83.457**	83.957**	8.281**	15.049**
Enviro-nment (E)	3	148.71**	107.199**	884.048**	43.291**	32.473**	86.473**	832.830**	3.515**	271.257**	826.969**	16.417*	156.509*
G x E	234	2.149**	1.589**	17.087**	0.560**	0.285**	0.866**	7.913**	0.029**	4.302**	14.223**	8.330**	1.526**]
E + (G x E)	237	4.006**	2.925**	28.061*	1.101**	0.693**	1.890**	18.355**	0.073**	7.681**	24.507**	8.420**	3.488**
E (Linear)	1	446.612**	321.596**	2652.146**	129.874**	97.418**	259.420**	2498.490**	10.544**	813.772**	2480.088**	46.251**	469.527**
G x E (Linear)	78	1.320	1.225	10.201	0.678*	0.236	0.806	10.637**	0.040**	4.743	17.755*	8.199*	1.794*
Pooled deviation	158	2.531**	1.748**	20.270**	0.494**	0.306**	0.795**	6.469**	0.022**	4.030**	12.299**	6.289*	1.374**
Pooled error	632	0.687	0.777	3.093	0.186	0.217	0.339	3.661	0.004	2.291	3.883	4.973	0.463

*, ** significantly at 5% and 1% levels, respectively.

the parents. The crosses showing stability involving both stable parents were Raj 3777 x KRL 1-4, Raj 3777 x Raj3077, UP2338 x Lok 1 and Job 79 x KRL 1-4 for grain yield. This indicated that genes were inherited from its parents but this relationship was not noticed in all the crosses. The cross Job673 x Raj3077 was stable but involving one stable parent. On the basis of these results in can be concluded that the inheritance of stability is different for different characters as well as for genotypes for the same characters.

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REACTION OF CERTAIN ADVANCED SPANISH GROUDNUT GENOTYPES TO POD ROT DISEASE

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Pod rot of groundnut gaining economic importance due to damage directly on pod yield. Deterioration of pods, beginning at maturity in the soil may be serious in some areas. It was reported to cause 34% and 70% pod yield loss in Senegal (Bouriquet and Jaubert, 1954) and Argentina (Macola, 1950) respectively. In U.S.A. loss in pod yield was varied from 5 to 50% depending upon geographical location. In India, it is reported to cause considerable yield loss in Karnataka, Uttar Pradesh, Maharastra Gujarat and Tamilnadu. The disease is complex in nature because of involvement of many soil prone fungi like *Rhizoctonia solani, Sclerotium* sp., *Fusarium* sp., *Macrophomina* sp., *Cylindrocladium* sp. and *Pythium* sp., and the dominance of one or two of these fungi vary from geographical location. (Mc Donald, 1969; Bouriquet and jaubert, 1954; Macole 1950). In Northern Karnataka, *Rhizoctonia* solani was frequently isolated from the affected pod (Gopal *et al.* 1994) and the pathogenicity was proved as described by Ramakrishna and Kolte (1988). Because of endemic nature of the disease in Northern Karnataka, certain advanced spanish groundnut genotyoes including a national check (JL 24) were screened for reaction topod rot caused by *Rhizoctonia solani* and assessed for pod yield both in pod rot sick plot and pod rot free plot and the results are reported.

Ten advanced spanish groundnut genotyoes were sown in two separate areas, one in pod rot sick plot and another in pod rot free plot for two years at Regional Research Station, Raichur to know the effect of pod to disease on pod yield, shelling (%) , test weight and oil content. The experiments were conducted in randomized block design with four replications with a plot size of 5x 2.1 m. spacing followed between rows and plants was 30 x 10 cm. The genotypes were raised according to package of practices (Anon, 1985). Fifty plants in each genotypes were screened against pod rot at harvest by following 1-5 scale where 1 is pods free from spots and 5 is more than 50% pod surface covered by black discoloration. Per cent disease index was calculated by formula proposed by Wheeler 91969). Based of the mean PDI of the two years, the genotypes were grouped as immune (disease free), resistant (0.5-10 PDI), moderately resistant (10.1 to 30 PDI) susceptible, (30.1 to 50 PDI) and highly susceptible (> 50 PDI). All the genotypes were harvested, pod yield and other ancillary parameters were recorded and subjected to pooled analysis (Sukhatma and Amble. 1985).

Pods of highly susceptible varieties showed various degrees of discoloration from superficial rusting to complete blackening of hulls. Early infected pods were under developed and remained pops. Black discolored pots were also found on pegs, stem and roots. The susceptible plants showed premature yellowing. junction between pods and peg normal and the pods were intact as in case of healthy plant. Of the ten genotypes screened for disease reaction, ICGV 86885 was found to be resistant followed by ICGS 11, INS 9013, DRG 12, KRG 2 and R 8806 which were moderately resistant and rest were either susceptibly or highly susceptible to the disease (Table 1). The susceptible check Jl 24 recorded 4.7 grade followed by Dh 40 (4.6) and KRG 1 (3.9). Resistance source for the individual pathogen were reported in literature, however, the utilization of these sources were not reported (Raj and Prasad, 1975; Shanmugam and Govindaswamy, 1973; Mathur *et al.* 1967). Ramakrishna and Kolte (1988) reported 10 groundnut germplasm with less than 11% pod rot infection caused by *Rhizoctonia solani.*They were SIG 37A, Racher 5-6, Daswa 1, OGI 28-206, OGI 14-4, GAUG 1, PS 113, TG 10, S 196 and J 11.

Results on pod yield loss clearly indicated the existence of greater variability among the genotypes tested (Table 1&2). The pod yield (kg/ha), shelling (%), 100 kernal weight (g) and oil content (%) were ranged from 4471 to 3382, 74.5 to 67.5, 45.1 5o 35.3, 48.8 to 47.1. respectively in disease free plot while in sick plot, it was 3856 to 1862, 69.7 to 57.1, 49.2 to 31.4

Table 1. Reaction to pod rot and pod yield loss in certain advanced spanish groundnut genotypes

		Pod yield kg/ha			Pod rot disease			
Sl No.	Genotypes	A	B	Per cent	Grade pod yield loss	Regction (1-5)	Foliage	Duration
1.	ICGS 11	3856	4048	4.91	2.1	MR	DG	134
2.	INS 9013	3785	4194	1081	2.0	MR	DG	115
3.	DORG 12	3782	4471	18.22	2.3	MR	DG	125
4.	KRG 2	3779	4346	15.00	2.0	MR	DG	122
5.	ICGV 86885	3625	3784	4.39	1.7	R	DG	120
6.	INS 9014	3534	4040	14.32	2.7	S	LG	105
7.	R 8806	3466	3795	9.49	2.2	MR	DG	120
8.	DH 40	2025	3382	67.01	4.6	HS	LG	105
9.	KRGI	1862	3403	82.76	3.9	HS	LG	106
10.	JL 24 (National Check)	2244	3566	5891	4.7	HS	LG	101
	C.D. at 5%	191	185					

A = Yield in sick plotB= Yield disease free plotDG - Dark green LG - Light green
R = Resistant, MR = Moderately reistant, S= Susceptible, HS = Highly susceptible

Table 2. Influenced of pod rot on shelling, 100 kernal weight and oil content in cartain advanced spanish groundnut genotypes

Sl	Genotypes	Sheeling			100 Kernal wqight (g)			Oil content		
		A	B	C	A	B	C	A	B	C
1.	ICGS 11	61.7	72.6	17.7	44.5	44.8	0.01	47.6	48.6	2.1
2.	INS 9013	61.5	67.5	9.8	37.5	39.4	5.1	47.5	48.5	2.1
3.	DORG 12	69.2	73.5	6.2	49.2	49.5	0.01	47.8	48.6	1.7
4.	KRG 2	69.5	71.6	3.0	42.3	44.5	5.2	48.3	48.8	1.0
5.	ICGV 86885	69.7	72.5	4.0	44.8	45.1	0.01	47.8	48.4	2.6
6.	INS 9014	67.4	69.6	3.3	36.8	39.5	7.3	47.5	48.7	2.5
7.	R 8806	70.0	71.5	2.1	35.4	39.5	11.6	47.8	48.6	1.7
8.	DH 40	57.1	74.5	30.5	31.4	35.3	12.4	45.1	48.1	6.7
9.	KRGI	58.8	72.8	23.8	31.8	35.6	11.9	46.3	48.6	4.9
10.	JL 24 (National Check)	60.6	4.4	-	3.5	3.9	-	2.9	NS	-
	CD at 5%	3.8	4.4	-	3.5	3.9	-	2.9	NS	-

A = Data sick plot B= Data from disease free plot C= per cent loss

and 48.3 to 43.5, respectively.

In general severe loss in yield, shelling, 100 kernal weight and oil content were recorded in susceptible genotypes compared to resistant and moderately resistant genotypes compared to resistant and moderately resistant genotypes. Highest pod yield loss of 82.7 per cent was recorded in KRGI followed by Dh 40 (67%) and JL 24 (58.9%). Significantly severe reduction in shelling (%) was recorded in Dh 40 (30.5%) followed by KRG 1 (23.8%) and Jl 24 (17.9%). Similarly, high reduction in 100 kernal weight and oil content were also recorded in the susceptibly genotypes viz., JL 24 (Table 2).

The genotypes of ICGV 86885, DRG 12, KRG 2, LCGS 11 and INS 9013 which recorded higher pod yields with less loss in shelling, oil content are under testing in multilocation and demonstration trials in Northern Karnataka and some (ICGV 86885, ICGS 11) are being used in hybridization programme to develop multiple disease resistant and high yielding varieties.

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RESPONSE OF RABI REDGRAM TO DATES OF SOWING AND ROW SPACINGS

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Pigeonpea is one of the important grain legume crops grown in *kharif* season in Andhra Pradesh. Present productivity of this crop is 568 kg/ha as against target of 874 kg/ha by the end of 2004-05. The major hurdle besides others, is management of *Heliothis* pest during *kharif* season. To realise maximum yield potential of pigeonpea, the possible alternative management technique is "Escape mechanism". *Rabi* pigeonpea escapes the period of peak *Heliothis* incidence during flowering period (Murthy, 1997).

Cultivation of pigeonpea during post rainy rainy season is a new concept and there is a scope to spread further in areas receive North-Eastern monsoon rains and having source of irrigation for one or two irrigations. After identifying a suitable crop for a situation, it is essential to develop agrotechniques for higher yield. Among all, suitable time of sowing and optimum spacing are crucial management factors for getting maximum yield. Hence, an experiment was conducted at Agricultural Research Station, Madhira during *rabi* 1998 and 1999 to identify the best time of sowing and optimum spacing for *rabi* pigeonpea.

Three inter row spacings (45 cm, 60 cm, and 90 cm) were tried under four dates of sowing viz. 15 September, 30 September, 15 October and 30 October at 15 days interval. The experiment was conducted in split plot design taking dates of sowing under main plots and spacings under sub plot treatments and replicated thrice. Fertilizers @ 20 kg N and 50 kg P_2O_5 per hectare was given to all treatment. Entire P_2O_5 and half of nitrogen was applied at the time sowing and remain half was applied as top dressing at flowering and pod formation. One pre-sowing irrigation and another at flowering and pod information stages as life saving irrigation was given. Recommended plant protection measures were followed.

Different dates of sowing exerted significant difference in branches per plant, pods per plant and seeds per pod as well as grain yield during both the years (Table 1). The crop sown on 15 and 30 September produced significantly higher number of branches per plant, pods per plant and seeds per pod and grain yield as compared to crop sown on 15 and 30 October. However, the difference between 15 and 30 September sowing was not significant for all the characters during both the years except for grain yield in the year 1998 in which 15 September sown crop recorded significantly higher grain yield than rest of the dates. The branches and pods per plant as well as grain yield decreased gradually with every 15 days delay in sowing after 30 September (Table 1). The reduction in grain yield in

Table 1. Cowth and yield attributes of rabi redgram as influenced by dates of sowing and spacing

	Height		Branches/plant		pods/plant		seeds/pod		grany yield (q/ha)		Pooled
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	(Q/ha)
Date of sowing											
D1. 15th september	89.77	102.44	10.00	9.88	140	113.33	3.58	3.39	28.4	18.1	23.25
D2.30th september	82.11	100.00	10.72	9.55	125	103.06	3.72	3.6	24.00	18.2	21.1
D3.15th october	70.88	103.66	10.54	6.04	98	59.22	3.59	3.23	13.2	11.6	12.4
D4.30th october	67.5	101.41	8.8	5.57	58	42.88	3.44	3.16	9.8	10.00	9.4
SED±	1.21	3.5	0.245	0.6	6.4	3.96	3.084	0.032	0.88	0.54	1.04
C.D. at 5%	2.98	NS	0.6	1.47	15.68	9.68	0.206	0.078	2.83	1.72	3.3
Spacings											
45 cm	74.6	103.00	10.07	8.28	110	79.5	3.53	3.35	22.1	15.2	18.65
60 cm	77.6	103.75	10.1	8.03	114	85.25	3.6	3.35	25.3	14.8	20.05
90 cm	80.5	101.41	9.9	6.98	102	74.13	3.61	3.33	15.9	13.6	14.75
SED ±	1.5	2.63	0.345	0.4	4.94	4.14	0.113	0.06	1.265	0.243	1.86
C.D. 5%	2.44	NS	NS	0.86	10.48	8.78	NS	NS	5.44	1.02	2.6

crop sown beyond 30 September was 44 and 55 percentage for crop sown on 15 and 30 October, respectively. Favourable temperature resulting in rapid growth in terms of height and pods per plant would have helped in realising higher grain yield in early sown crop. On the other hand lower temperature during growth of late sown crops resulted in poor growth as reflected in the lower plant height might be the reasons for poor yields. Similar results of higher grain yield in early sown crop were also reported by Padhi, (1995).

Different yield attributing characters were markedly influenced by inter row spacing during both the years except seeds per pod. The number of pods and branches per plant were significantly higher under 45 cm and 60 cm spacing than 90 cm. However, the two spacing were statistically at par during both the years. Effect of spacing on seeds per pod was not significant. Significantly higher grain yield was recorded in crop sown with 60 cm spacing than 90cm but it was statistically at par with 45cm spacing during the year 1998. However, in 1999, 45cm spacing registered the highest grain yield than 60 cm as well as 90 cm. Under pooled analysis 60 cm spacing registered significantly higher grain yield than 45 cm and 90cm, respectively spacings. It might be due to higher plant height and pods per plant in 60 cm spacing resulting in higher yield.

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ASSESSMENT OF SALINE WATER INDUCED SALT STRESS AT WATER RESOURCES IN TEMPEST-HIT ORISSA

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On 29th October 1999, century worst most devastating cyclone hit Orissa coast with a wind speed of 290 kmph, rampaged coastal districts and destroyed bumber crops standing on the field spread across 3.23 lakh area. During super cyclone sea, waves gone up to 7 m high and had rushed in and places traveled up to 15 km inland and turned the soil and water resources saline (India Today, 1999), which otherwise were presumed to be non saline as those had been in use for growing rice since long. There is no systematic data record available with respect to salinity of various water resources and its fluctuation with seasons in coastal zone of Orissa. Although it was observed that vast tracts of paddy fields were brutally damaged by sea-water during super-cyclone and its' restricted back flow thereafter. Eighty percent of state's economy depends on farming, which developed an urge to determine the salt stress existing in water resources and its possible recuperation in near future. An investigation was thus undertaken to explore the salt stress induced in water resources at cyclone hit coastal districts in Orissa.

Fifty-seven water samples comprising of surface and ground water collected from different places at eight districts, which were affected by seawater inundation, in Orissa. Samples were grouped into two broad classes viz., surface and ground water which further subdivided into Pond water, standing water on cultivated field and rivulet/canal/ditch water under surface and open-well and tube-well water under ground water resources. The relevant chemical properties of water are discussed.

The salt stress in water samples was assessed as per the water quality classification criteria given by Das (1998), which was based on the observations generated in the coastal zone of West Bengal, as follows.

Name of class	Electrical conductivity (dS m^{-1})	Sodium adsorption ratio (mmol/l)$^{0.5}$
Very good (I)	<1.0	≤ 10
		≥ 10
Good (II)	1.0 - 2.0	≤ 10
		≥ 10
Marginally saline (III)	2.0 - 4.0	≤ 10
		≥ 10
Saline (IV)	>4.0	≤ 10
		≥ 10

The sodium adsorption ratio (SAR) of water was < 10 (mmol/l)$^{0.5}$ and pH ranged between 5.44 to 7.88 i.e. moderately acidic to slightly alkaline therefore only ECw was considered for classifying the water sources. Data in Table 1 reveal that in general

Table 1. Differential distribution of salinity related salient characteristics in water collected from cyclone affected coastal districts in Orissa

District	Water quality class	Parameters	Samples collected from different sources				
			Surface water			Ground water	
			Pond water	Standing water on field (SWF)	Canal/ rivulet/ditch	Open -well	Tube -well
Jagatsingpur	I	ECw (dSm^{-1})	-	0.22	0.32	-	0.61
		SAR (mmol/l)$^{0.5}$	-	0.82	0.16	-	0.20
		Ca : Mg	-	1.30	1.35	-	1.06
		Cl$^-$(meq/l	-	0.45	0.67	-	0.55
	II	ECw (d Sm^{-1})	1.37	-	1.55	-	1.56
		SAR (mmol/l)$^{0.5}$	0.82	-	0.54	-	0.28
		Ca : Mg	0.62	-	2.74	-	1.22
		Cl$^-$ meq/l	12.20	-	11.90	-	11.70
	III	ECw (d Sm^{-1})	6.67	4.14	-	5.42	-
		SAR (mmol/l)$^{0.5}$	2.96	1.13	-	2.96	-
		Ca : Mg	0.28	0.25	-	0.39	-
		Cl$^-$ (meq/l)	73.40	47.20	-	55.20	-
Kendrapada	I	ECw (dS m^{-1})	0.24	-	-	-	-
		SAR (mmol/l)$^{0.5}$	0.15	-	-	-	-
		Ca : Mg	0.75	-	-	-	-
		Cl$^-$ (meq/l)	2.70	-	-	-	-
	II	ECw (dS m^{-1})	-	-	-	-	1.52
		SAR (mmol/l)$^{0.5}$	-	-	-	-	0.32
		Ca : Mg	-	-	-	-	0.72
		Cl$^-$ (meq/l)	-	-	-	-	10.85
	III	ECw (dS m^{-1})	-	2.29	-	-	2.61
		SAR (mmol/l)$^{0.5}$	-	0.86	-	-	2.54
		Ca : Mg	-	0.39	-	-	0.87
		Cl$^-$ (meq/l)	-	18.10	-	-	26.80
	IV	ECw (dS m^{-1})	-	7.20	-	-	4.00
		SAR (mmol/l)$^{0.5}$	-	3.10	-	-	3.10
		Ca : Mg	-	0.19	-	-	0.76
		Cl$^-$ (meq/l)	-	78.50	-	-	37.20
Puri	I	ECw (dS m^{-1})	0.15	0.26	-	0.48	0.30
		SAR (mmol/l)$^{0.5}$	0.21	1.37	-	1.39	1.03
		Ca : Mg	0.28	0.37	-	2.51	1.12
		Cl$^-$ (meq/l)	0.90	2.10	-	6.80	1.77
	II	ECw (dS m^{-1})	-	-	-	1.77	1.73

Contd

Tablel 1. contd.

District	Water quality class	Parameters	Samples collected from different sources				
			Surface water			Ground water	
			Pond water	Standing water on field (SWF)	Canal/ rivulet/ditch	Open -well	Tube -well
		SAR $(mmol/l)^{0.5}$	-	-	-	0.86	1.19
		Ca : Mg	-	-	-	0.81	1.19
		Cl^- (meq/l)	-	-	-	11.60	15.70
	III	ECw $(dS\ m^{-1})$	-	-	-	-	2.29
		SAR $(mmol/l)^{0.5}$	-	-	-	-	0.49
		Ca : Mg	-	-	-	-	0.77
		Cl^- (meq/l)	-	-	-	-	17.00
Cuttack	I	ECw $(dS\ m^{-1})$	0.51	-	-	-	0.33
		SAR $(mmol/l)^{0.5}$	1.38	-	-	-	1.59
		Ca : Mg	1.00	-	-	-	1.00
		Cl^- (meq/l)	0.90	-	-	-	0.90
	IV	ECw $(dS\ m^{-1})$	-	-	8.24	-	-
		SAR $(mmol/l)^{0.5}$	-	-	4.61	-	-
		Ca : Mg	-	-	0.56	-	-
		Cl^- (meq/l)	-	-	86.80	-	-
Khurda	I	ECw $(dS\ m^{-1})$	-	-	-	-	0.31
		SAR $(mmol/l)^{0.5}$	-	-	-	-	-
		Ca : Mg	-	-	-	-	-
		Cl^- (meq/l)	-	-	-	-	0.50
	IV	ECw $(dS\ m^{-1})$	-	-	5.94	-	-
		SAR $(mmol/l)^{0.5}$	-	-	4.08	-	-
		Ca : Mg	-	-	0.72	-	-
		Cl^- (meq/l)	-	-	54.55	-	-
Ganjam	I	ECw $(dS\ m^{-1})$	0.34	-	-	-	-
		SAR $(mmol/l)^{0.5}$	1.81	-	-	-	-
		Ca : Mg	0.34	-	-	-	-
		Cl^- (meq/l)	2.60	-	-	-	-
	II	ECw $(dS\ m^{-1})$	-	1.03	-	-	-
		SAR $(mmol/l)^{0.5}$	-	0.37	-	-	-
		Ca : Mg	-	0.81	-	-	-
		Cl^- (meq/l)	-	7.80	-	-	-
	III	ECw $(dS\ m^{-1})$	-	-	-	1.24	1.08
		SAR $(mmol/l)^{0.5}$	-	-	-	0.44	1.30

Contd

Table 1. contd

District	Water quality class	Parameters	Surface water: Pond water	Surface water: Standing water on field (SWF)	Surface water: Canal/ rivulet/ditch	Ground water: Open -well	Ground water: Tube -well
		Ca : Mg	-	-	-	1.77	0.82
		Cl$^-$ (meq/l)	-	-	-	7.35	6.20
	IV	ECw (dS m^{-1})	-	-	-	-	8.03
		SAR (mmol/l)$^{0.5}$	-	-	-	-	7.16
		Ca : Mg	-	-	-	-	0.58
		Cl$^-$ (meq/l)	-	-	-	-	54.30
Bhadrak	I	ECw (dS m^{-1})	-	-	0.26	-	0.65
		SAR (mmol/l)$^{0.5}$	-	-	0.57	-	0.25
		Ca : Mg	-	-	0.40	-	1.52
		Cl$^-$ (meq/l)	-	-	2.20	-	1.80
	II	ECw (dS m^{-1})	-	1.09	-	-	-
		SAR (mmol/l)$^{0.5}$	-	1.96	-	-	-
		Ca : Mg	-	0.29	-	-	-
		Cl$^-$ (meq/l)	-	5.00	-	-	-
Baleswar	I	ECw (dS m^{-1})	-	-	-	-	0.49
		SAR (mmol/l)$^{0.5}$	-	-	-	-	0.73
		Ca : Mg	-	-	-	-	1.14
		Cl$^-$ (meq/l)	-	-	-	-	1.27

higher value of p was registered in the surface water as compared to sub-soil water sources, which may be attributed to the good aeration induced oxidation at surface in contrast to anaerobic situation prevailed at sub-soil water. By following the above classification 37 percent water at canal/ ditch/rivulet was highly saline as against 28 percent at pond and 20 recent at standing water on cultivated field which further followed by open-well (12%) and tube-well (15%) water. As the pH was slightly alkaline (7.88), SAR was <10 (mmol/l)$^{0.5}$ and presence of Cl$^-$ in excess decreased the possibility of the presence of Na-borate in water and thus the fear of boron toxicity (USDA Handbook, 1954) might have eliminated. Low Ca: Mg was observed in most of the water samples, which may also corroborated the fact of sea water inundation as sea water contains more Mg than Ca. The lowest Ca : Mg ratio (0.18) was noticed in the water collected form Paradeep and Puri Sadar blocks at Jagatsinghpur and Pui districts, respectively, followed by water collected from Mahakalpara block at Kendrapada district. In addition to water collected from Erasama, Astarang and Brahamagiri blocks also showed loe Ca : Mg i.e within the range of 0.22 to 0.94. Out of fifty-seven water samples thirty-six samples contained Mg to the tune of 1.14 to 5.1 times more than the Ca concentration present in the water. Presence of more Mg with respect to Ca may disturb the Ca-Mg equilibrium and Mg-K antagonism may induce K deficiency in crops if the water will be used for irrigation (Gupta and Khosla, 1982). In case of anions, an enormous presence of Cl^- was noted followed by SO_4^{-2} and others.

As per the magnitude of salt stress present, Jagatsinghpur was maximum affected i.e 31 per cent water was highly saline ($ECw>0$ d Sm^{-1}) as against 25 percent registered at Kendrapapda > Puri (21%) > Ganjam (16%)> Khurda (14%). But as per the coverage of water resources under salt stress i.e $ECw \geq 2.0$ dS m^{-1}, 50 per cent water at Kendrapada was saline duly followed by Jagatsinghpur (31%) and Puri (28%) districts.

The salt stress prevalent in water may be reduced or minimised by maximum exploitation of those water sources for various purposs including supply of irrigation for various crops and their eventual fill up by good quality rain water during subsequent monsoon may help to revert the quality which was substantially degraded.

Differential distribution of salt stress in water also provides help to adopt proper water management practices for reducing water salinity and to grow salinity tolerant crops suitable in cyclone affected eight coastal districts of Orissa.

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EFFECT OF PHOSPHORUS AND ZINC ON DRY MATTER, UPTAKE OF NUTRIENTS AND QUALITY OF CLUSTERBEAN [*CYAMOPSIS TETRAGONOLOBA* (L) TABU.]

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Clusterbean [*cyamopsis tetragonoloba* (L) Tabu.] is an important leguminous crop mostly grown in arid and semi arid areas food, fodder, vegetable and industrial purposes. However, it is grown on marginal lands in *kharif* season with no fertilizer and hence total biomass production and nutrient uptake is adversely affected. Therefore, looking the importance of balanced fertilization in clusterbean, the present investigation was undertaken to assess the effect of phosphorus and zinc on dry matter accumulation, nutrient uptake and quality of clusterbean.

A field experiment consisting of four levels of both phosphorus (0. 20, 40 and 60 kg P_2O_5 ha^{-1}) and Zinc (0, 2.5, 5 and 7.5 kg Zn ha^{-1}) was taken at College of Agricultural, Bikaner during *khrif* 1992-2000. Sixteen treatment combinations were tested in randomised block design with four replications on loamy sand soil having pH 8.0, available phosphorus 19.24 kg P_2O_5 ha^{-1} available zinc 0.41 ppm. Nitrogen @ 25 kg ha^{-1} was applied as basal dose through Urea & DAP. DAP and ZnO were used as per treatment as a source of phosphorus and Zinc, respectively. Variety 'RGC 936' was sown on July 19, 2000 at 30 cm. row spacing.

Application of phosphorus @ 40 kg P_2O_5 ha^{-1} significantly increased the dry matter accumulation per meter row length by 20.57 and 7.81 per cent over control and 20 kg P_2O_5 ha^{-1}, respectively (Table 1). The similar trend was observed in straw and seed of clusterbean. Protein and gum content also increased significantly due to application of 40 kg P_2O_5 ha^{-1} in comparison to control and 20 kg P_2O_5 ha^{-1}. This increase might be the result of vigorous growth of plants by enhanced photo-synthesis, fat and protein synthesis due to optimum availability of phosphorus at this level. Similar results were also reported by Bhadoria *et al.* (1997).

The data further reveal that the application of 5 kg Zn ha^{-1} significantly increased the dry matter accumulation in clusterbean over control and 2.5 kg Zn ha^{-1}. Application of Zn beyond 5 kg Zn ha^{-1} resulted in decrease in dry matter yield of clusterbean. Similar trend was noted for nitrogen, phosphorus and zinc content and uptake. Protein and gum content also showed a similar pattern of response to Zn except that application of Zn @ 7.5 kg ha^{-1} was found to be at par with 5 kg Zn ha^{-1}. This increase in dry matter accumulation, uptake, protein and gum content might be partly due to role of Zn in auxin synthesis,

Table 1. Effect of phosphorus and zinc on dry matter accumulation, content and uptake of nutrients and quality of clusterbean

Treatments		Nutrietn content						Nutrient uptkae				
	Dry matter accumulation (g per meter row length	Nitrogen (%)		Phosphorus (%)		Zince (ppm)		Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Zinc (g ha^{-1})	Protein content (%)	Gum content (%)
		Seed	Straw	Seed	Straw	Seed	Straw					
Phosphorus (kg P_2O_5 ha^{-1})												
0	98.50	3.79	0.813	0.308	0.072	29.87	20.43	50.327	4290	73.58	23.68	27.34
20	110.16	4.07	0.952	0.340	0.082	31.76	21.93	64.453	5.642	90.16	25.44	29.02
40	118.77	4.25	1.064	0.352	0.092	31.90	22.55	75.162	6.320	99.55	26.56	30.34
60	116.41	4.21	1.011	0.350	0.089	29.47	19.88	71.433	0.087	86.25	26.31	30.53
Zinc (kg Zn ha^{-1})												
0	99.47	3.87	0.854	0.348	0.084	27.90	15.62	53.119	5.010	60.61	24.18	27.67
2.5	110.31	4.04	0.842	0.361	0.087	30.98	21.10	64.514	6.102	87.24	25.25	28.11
5.0	118.18	4.24	1.053	0.336	0.082	32.98	23.91	73.639	5.970	101.62	26.56	30.26
7.5	115.88	4.17	0.991	0.304	0.078	32.11	24.06	69.634	5.257	100.07	26.06	30.19
C.D. (P=0.05)	7.84	0.12	0.026	0.011	0.003	0.84	0.63	5.692	0.472	7.24	1.09	1.01

higher meristematic activities and higher uptake of nitrogen and phosphorus at 5 kg Zn ha^{-1} and partly due to higher seed and straw yield. At this level. Similar findings have also been observed by Bharat Singh *et al.* (1988).

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EFFECT OF SOWING DATES AND NITROGEN LEVELS ON NUTRIENT UPTAKE AND QUALITY OF ISABGOL (*PLANTAGO OVATA FORSK)*

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Blond psyllium or isabgol is predominantly cultivated in Gujarat state and adjoining districts of Gujarat namely, Sirohi and Jalore in Rajasthan have emerged as leading producer of isabgol in the last 5-6 years. Being economically important crop, it was introduced in research experiments at College of Agriculture, Bikaner in 1998-99 for agronomical studies. To harvest the higher yield of this crop in Indira Gandhi Canl area of North-west Rajasthan, there is an urgent need to develop agro-techniques especially the sowing time and nitrogen management. Hence, the present investigation was undertaken to find out the optimum sowing time and nutrient requirement for higher production of blond psyllium.

The field experiment was conducted in randomised block design at the College of Agriculture, Bikaner during the winter season of 1998-99. The treatments comprised of four sowing dates [25th Oct. (D_1), 4 Nov. (D_2), 14 Nov. (D_3) and 24 Nov. (D4)] and four levels of nitrogen (0, 15, 30 and 45 kg N/ha). The soil was loamy sand in texture, low in organic carbon (0.06%), available nitrogen (64.50 kg N/ha) and available phosphorus (9.8 kg P/ha) and medium in available potassium (11.34 kg K/ha) with pH 8.2.'Gujarat Isabgol 2', blond psyllium was sown at 30 cm. row spacing using a seed rate of 6 kg/ha. The crop was harvested between 15th to 30th March depending upon sowing time. Swelling factor in blond psyllium was determined by dipping 1 g seed in 20 ml water for overnight and swollen mass was recorded next day (Kalyanasundaram *et al.*, 1982).

The study showed that sate of sowing had no effect on nitrogen and phosphorus content in seed and straw as well as on swelling factor and protein content (Table 1). The nitrogen uptake was significantly higher when the blond psyllium was sown on 4 November (D_2) in comparison to 25 October (D1), 14 November (D3) and 24 November (D4). Phosphorus uptake was found to be significantly higher when blond psyllium was sown on 25 October or 4th November in comparison to 14th November and 24th November. The significant decrease in total nitrogen and phosphorus uptake by beyond 25 October (D1) sowing could be attributed to poor accumulation of dry-matter and significant reduction in yield. The results are in close conformity with the findings of Singh (1997). The data further revealed that application of nitrogen @ 45 kg N/ha recorded significantly higher nitrogen uptake over the application of 15 and 30 N kg/ha. However, application of nitrogen @ 30 kg/ha resulted in significantly higher uptake of phosphorus over no nitrogen and 15 kg N/ha and it was at par with the application of

Table 1. Effect of sowing dates and itrogen levels on nutrient uptake and quality of Isabgol

Treatment	Nitrogen content		Phosphorus content		Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Swelling factor (CC/g)	Protein content (%)
	Seed	Straw	Seed	Straw	Seed	Straw	Total	Seed	Straw	Total		
Sowing dates												
25 October (D_1)	2.16	0.55	0.87	0.35	23.49	18.24	41.73	9.44	10.07	19.51	12.25	13.53
4 November (D_2)	2.27	0.55	0.88	0.318	22.79	22.51	45.30	9.22	9.80	19.63	12.16	13.53
14 November (D_3)	2.29	0.61	0.90	0.318	16.90	16.22	35.82	7.59	8.10	15.70	12.08	14.32
24 November (D_4)	2.29	0.71	0.90	0.312	16.08	11.93	28.01	5.97	6.43	12.41	11.83	14.32
C.D. at 5%	NS	0.06	NS	NS	1.86	2.09	2.79	0.70	0.79	1.43	NS	NS
***Nitrogen levels* (kg/ha)**												
N_0	1.83	0.45	0.88	0.313	11.30	8.33	19.63	5.34	5.72	11.06	13.66	11.45
N_{15}	2.10	0.53	0.88	0.315	18.25	14.49	32.75	8.05	8.62	16.68	12.50	12.2
N_{30}	2.33	0.65	0.89	0.318	23.56	20.62	44.18	9.16	9.81	18.98	11.50	14.58
N_{45}	2.70	0.78	0.90	0.318	28.85	24.46	54.31	9.67	10.26	19.93	10.60	16.92
C.D. at 5%	0.18	0.06	NS	NS	1.86	2.09	2.79	0.70	0.69	1.43	0.45	1.10

Table 2. Combined effect of sowing dates and nitrogen levels on total nitrogen uptake (kg/ha) by Isabgol

Nitrogen Levels (Kg N/ha)	Date of sowing			
	D1	D2	D3	D4
0	25.14	22.16	17.81	13.39
15	36.66	39.26	27.09	27.98
30	47.44	51.22	42.79	36.60
45	57.68	65.28	55.60	38.40
CD at 5%	-	5.59	-	-

45 kg N/ha. Parihar and Singh (1995) obtained maximum uptake of nitrogen and phosphorus with the application of 45 kg N/ha.

The positive effect of different doses of N was not marked on marketing value of seed and its maximum value was recorded at zero level of nitrogen. However, protein content of seed increased significantly with increase in each level of nitrogen from no nitrogen to 45 kg N/ha. Mafeshwari *et* (2000) recorded no positive effect of different doses of nitrogen on swelling factor in blond psyllium.

A significant interaction effect was noted between time of sowing and levels of nitrogen on total nitrogen uptake by blond psyllium (Table 2). The maximum and significantly higher total nitrogen uptake by blond psyllium was recorded in 4 November sown crop fertilized with 45 kg N/ha (25 October and 4 November) under higher doses of nitrogen might be attributed to favourable climatic conditions for higher dry matter accumulation and nitrogen uptake.

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EFFECT OF DIFFERENT LEVELS OF NITROGEN AND SULPHUR ON CONTENT AND UPTAKE OF NUTRIENT AND QUALITY OF TAKAMIRA (*ERUCA SATIVA* L.)

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Oilseeds have an important position in Indian economy occupying the position of second largest Agricultural commodity after cereals and sharing 14 per cent of the country's gross cropped area and accounting for nearly 5 per cent of the gross national products. Despite spectacular increase in oilseed production in the country, the problem of low productivity continues to be worrying issue. The productivity of oilseeds was 935 kg ha^{-1} (1998-99) as compared to the word level of 1632 kg ha^{-1}. Repeseed and mustard group occupy a prominent place among oilseed crops. Taramira also known as "Rocket Salad", is a neglected member of rapeseed and mustard group and has tremendous potential even under the situation of resources constraints. Its oil content varies from 32-37 per cent. Under the situation of late harvesting of *kharif* crop or failure of *rabi* crop due to moisture scarcity it can be taken as catch crop. It can be grown on variety of soil on conserved moisture as it is relatively hardy and there is no danger of grazing by animals. Work done on the fertilizer requirement of taramira is very meagre and need immediate attention to raise the production per unit area of both seed as well as oil. One of the immediate ways for increasing production of taramira is improving crop nutrition through balanced fertilization. The present investigation was undertaken to assess the effect of different nitrogen and sulphur levels on content and uptake of nutrient and quality of taramira.

A field experiment consisting four levels of both nitrogen (0, 20, 40 and 60 kg ha^{-1}) and sulphur (0, 20, 40 and 60 kg ha^{-1}) was conducted at College of Agriculture, Beechwal, Bikaner during *rabi* 1998-99. Sixteen treatment combination with three replication were tested in factorial randomized block design on loamy sand soil containing 64.4 kg ha^{-1} available nitrogen and available sulphur 9.81 ppm with soil pH 8.2. Urea and gypsum were used as per treatment as a source of nitrogen and sulphur, respectively as basal application. Variety 'RTM-1' was sown on 12th October 1998 at 30 cm row spacing.

Application of 40 kg N ha^{-1} significantly increase the content and uptake of nitrogen and sulphur in both and straw of taramira, over control. 40 kg nitrogen ha^{-1} also increased the protein and oil content of seed significantly by 21.79 and 15.97 per cent, respectively (Table 1). This increase might be due to the increase availability of the nutrient in low nutrients status soils which results in better growth of root and shoot of plant and result in increased

Table 1. Effect of different levels of nitrogen and sulphur on content and uptake of nutrient and quality of taramira (*Eruca sativa* L.)

Treatments	Nutrients content (%)				Nutrient uptake			
	Nitrogen		Sulphur		Nitrogen (kg ha^{-1})	Sulphur (kg ha^{-1})	Protein content (%)	Oil content (%)
	Seed	Straw	Seed	Straw				
Nitrogen (Kg ha^{-1})								
0	2.57	0.515	0.249	0.113	36.726	5.261	16.06	29.80
20	2.91	0.573	0.279	0.124	49.299	6.855	18.19	32.66
40	3.13	0.611	0.307	0.132	58.455	8.231	19.56	34.56
60	3.17	0.613	0.309	0.135	59.397	8.431	19.81	35.04
C.D. at 5%	0.14	0.031	0.019	0.006	4.36	0.438	0.78	1.68
Sulphur (kg ha^{-1})								
0	2.71	0.517	0.230	0.106	38.607	4.945	16.94	29.66
20	2.90	0.569	0.274	0.122	49.092	6.759	18.12	32.17
40	3.05	0.607	0.309	0.134	56.882	8.262	19.06	34.26
60	3.12	0.619	0.331	0.142	59.112	8.924	19.50	35.97
C.D. at 5%	0.14	0.031	0.019	0.006	4.36	0.438	0.78	1.68

absorption of nutrient, vigorous growth of plant by enhance photosynthesis, fat and protein synthesis. Jain (1988) also reported similar results for taramira and Sharma *et al.* (1994) in mustard.

The data further revealed that application of 40 kg S ha^{-1} significantly increase the content and uptake of nitrogen in both seed and straw over control. Whereas application of 60 Kg S ha^{-1} significantly increase the sulphur uptake and content in both seed and straw over control. Application of 60 kg S ha^{-1} significantly increase the oil content by 21.27 per cent over control (Table 1) whereas 40 kg sulphur ha^{-1} significantly increased the protein content of seed by 12.51 per cent over control (Table 1). This increase might be due to increase concentration of sulphur in soil solution, which in turns result in great absorption of nutrients. The synthesis of several co-enzymes like, co-enzyme-A, lipoic-acid may also be influenced by sulphur in plant tissue and result in increased oil content in seed. Similar observations were recorded by Singh (1993) for taramira, Singh and Kumar (1996) and Tomar *et al.* (1997) in mustard.]

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YIELD COMPONENTS OF GREENGRAM [*VIGNA RADIATA* (L.)] AS INFLUENCED BY PHOSPHORUS AND THIOUREA

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Being pulse crop of short duration, greengram (*Vigna radiata*) fits well under fragile agroclimatic conditions of arid regions of Rajasthan. The productivity of this crop is very low in this region due to lack of phosphorus fertilization, poor germination and improper dry-matter partitioning. Use of thiourea as seed treatment and foliar spray have been reported to increase yield and yield attributes in mustard, fodder pearlmillet, cowpea, etc. (Sahu *et al.*,1993). However, there is a lack of information on these aspects in green gram. Therefore, an investigation was conducted to find out response of greengram to levels of phosphorus and thiourea.

A field experiment consisting of 4 levels of phosphorus (0, 20, 40 and 60 kg P_2O_5/ha) and 5 modes of thiourea application [Control (TU_0), water soaking (TU_W), Seed treatment (TU_s), foliar spray of thiourea at 30 days after sowing i.e at flowering (TU_F), and thiourea seed treatment + foliar spray at flowering (Tu_{SF})] was undertaken at College of Agriculture, Bikaner during *kharif* 2000. The soil of the experimental site was loamy sand with pH value of 8.2, poor organic carbon (0.05%), and low water retentivity (170 mm/m depth). The amount of available N,P and K in the soil were 69.6, 9.2 and 161.5 kg/ha, respectively. Variety 'K 851' was sown on 25 July, 2000 at 30cm row spacing. Entire dose of phosphorus as per treatment alongwith a common dose of 30 kg N/ha was applied as basal. Seeds were soaked for 4 hours in 500 ppm thiourea solution in the case of seed treatment. Same concentration of thiourea was used for foliar spray.

The results of he field study revealed that the application of 40 kg P_2O_5/ha gave significantly higher yield in comparison to control and 20 kg P_2O_5 ha (Table 1). The increase in grain yield with the application of 20, 40 and 60 kg P_2O_5/ha was in the order of 19.5, 28.7 and 31.3 per cent over control, respectively. These variations in yield might be attributed to beneficial influence of phosphorus on plant height, number of branches/plant, pods/plant, grains/pod and test weight. Similar results were also reported by Thakuar *et al.* (1999).

The study further indicated that TU_{SF} treatment significantly increased the yield attributes and yield of greengram over all other thiourea treatments (TU_0, TU_W, TU_S and TU_F). The increase in grain yield with the treatments TU_{SF} was to the tune of 18.2, 15.7, 10.3 and 9.2 per cent over TU_0, TU_W, TU_S and TU_F, respectively. This might be attributed to the beneficial effect of thiourea on seed germination, seedling growth,

Table 1. Effect of phosphorus and thiourea on growt, yield attributes and yield of greengram

Treatment	Plant height	No. of branches/ plant	Pods/ plant	Grains/ pod	Test weight (g)	Grain yield (q/ha)
Phosphorus (P_2O_5 kg/ha)						
0	32.28	4.07	18.46	7.41	34.20	5.74
20	34.71	4.82	19.56	7.79	35.70	6.86
40	36.84	5.29	20.53	8.15	36.82	7.39
60	36.98	5.42	20.84	8.18	36.90	7.54
CD at 5%	0.90	0.32	0.80	0.30	1.11	0.22
Sulphur (kg S/ha)						
TU_0	33.39	4.44	19.00	7.40	34.64	6.42
TU_W	33.53	4.61	19.51	7.52	35.01	6.56
TU_S	35.59	4.91	19.91	7.90	36.17	6.88
TU_F	35.72	5.05	19.94	8.01	36.18	6.95
TU_{SF}	37.79	5.49	20.87	8.58	37.53	7.59
CD at 5%	1.00	0.35	0.89	0.33	1.24	0.24

chlorophyll content, biomass production and better dry matter partitioning. Similar results have also been reported by Parihar *et al.* (1988) and Sahu *et a.* (1993).

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STUDIES ON RELATIONSHIP OF NUTRIENT AVAILABILITY INDICES P FRACTIONS WITH PRODUCTIVITY AND UPTAKE FOLLOWING ROCKPHOSPHATES APPLICATION IN MOUNTAIN ACID SOIL

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Phosphorus is one of the essential primary nutrient for plant growth. Most of the Indian soils particularly acidic soils are low to medium in available P (Ramamoorthy and Bajaj, 1969). The main problem in the water soluble fertilizers is that, whatever H_2PO_4 they release, most of it get fixed in acid soils. Moreover water soluble fertilizers are costly for a normal farmer. Therefore, it is better to use cheaper alternate source like rockphosphate African rockphosphates like Gaffsa, Tebessa and Youssofia are more reactive as compared to mussoorie rockphosphate. Rockphosphate is slow release P fertilizers and this properly assume special significance in acid soils, where the rate of dissolution of P is generally less of a problem then its reversion to relatively less available from. It act as amendment in these soils and also add other nutrients such as Ca, Mg, Zn, Cu, Mn and Fe. It is important to work out the relationship between yield, uptake different forms of available P and different P fractions under different treatments of rockphosphate, because very less work has been done on this aspect.

A field experiment was conducted CSK HPKV on farm on wheat and maize during rabi, 1995-96 and kharif, 1996. The soil was Typic hapludalf having silty clay loam texture, and acidic in reaction (pH 5.6). Oganic carbon, available N, P and K was 10 mg/kg 361, 20 and 316 kg/ha, respectively. The CEC of the soil was 11.4 cmol (p^+)/kg and was having P-fixing capacity 600mg/kg. The treatments were control. Tebessa Gaffsa, Youssofia and mussoorie rockphosphae @ 250 and 500 kg/ha (one strike) and SSP @ 25 and 50 kg/ha (i.e. 250 and 500 kg/ha for ten crops). Rockphosphate was applied to ten crops (wheat and maize) in one stroke, however SSP was applied to each crop. Therefore P_2O_5 dose was same for all the fertilizers sources. The design was randomized block. Correlations between different parameter were worked out by standard procedures (Gomez and Gomez, 1984).

Relationship of wheat productivity and P uptake with P availability indices

As evident from Table 1, Olsen and citrate soluble-P contents in soil at sowing and at ear formation stage influenced the yield and P uptake at ear formation as well as at harvest of wheat positively and significantly.

The Olsen and citrate soluble-P in the soil before sowing of the crop demonstrated a significant correlation with dry matter yield at ear formation stage, the values of 'r' were about 0.831* and 0.794*, respectively. The corresponding values of these two P availability indices with grain yield at harvest were 0.730* and 0.600*. The value of coefficient of correlation (r) between Olsen and citrate soluble P with P uptake were 0.899* and 0.805* at ear formation and 0.885 and 0789* at harvest, respectively. Likewise, Olsen and citrate soluble-P in the soil at ear formation stage of the crop also showed a significantly and positive correlation with dry matter yield at ear formation, the values of 'r' were 0.726* and 0.809* respectively. The corresponding values of these P availability indices with grain yield at harvest were 0.700* and 0.715*. Olsen and citrate soluble-P with P uptake were 0.747* and 0.880* at ear formation and 0.760 and 0.878* at harvest, respectively. This showed that around 53 and 36% individual variation in grain yield is explained by Olsen and citrate soluble P content alone determined at sowing, whereas this contribution was 48 and 51% for Olsen and citrate soluble -P determined at ear formation stage, respectively.

Similar to wheat, in case of maize, Olsen-P and citrate soluble-P contents in soil at sowing and tasseling influenced the yield and P uptake at tasseling and at harvest stage of the crop significantly and in a positive manner.

Olsen and citrate soluble P in the soil at sowing of maize revealed a significant

Table 1. Correlation coefficient indicating the relationship between P availability indices with productivity amd P uptake by wheat and maize

	Wheat			
	Ear formation		Harvest	
	Dry matter	P uptake	Grain	Total P uptake
At sowing				
a). Olsen's P	0.831*	0.899*	0.730*	0.865*
b). Citrate P	0.794*	0.805*	0.600*	0.789*
At Ear Formation				
a). Olsen's P	0.726*	0.747*	0.700*	0.760*
b.) Citrate P	0.809*	0.880*	0.715*	0.878*
	Maize			
	Tasseling		Harvest	
	Dry matter	P uptake	Grain	Total P uptake
At sowing				
a). Olsen's P	0.800*	0.878*	0.898*	0.872*
b). Citrate P	0.607	0.674*	0.684*	0.601*
Tasseling				
a). Olsen's P	0.837*	0.872*	0.860*	0.882*
b.) Citrate P	0.770*	0.804*	0.763*	0.679*

* Significnat at 5% level.

correlation with grain yield at harvest and the values were 0.898* and 0.684*, respectively (Table 1). Similarly. Olsen and citrate soluble-P in soil at sowing and tasseling stage of maize also demonstrated a significant positive correlation with dry matter yield at tasseling and grain yield and P uptake at harvest of the crops. Similar result were also reported by Sharma *et al.*(1980).

Relationship of crop productivity and P uptake with different P-fractions

Different P-fractions viz. Fe-P, Al-P and Ca-P influenced the yield and P uptake at ear formation and at harvest stage significantly and positively (Table 2). On an average, around 36 to 50% and 57 to 73% variations in yield and P uptake at harvest were attributed to all the three determined P-fractions together. Tripathi and Minhas (1991) Datta (1986) Sharma *et al.* (1980) also determined the similar type of relationship between different P-fractions with wheat yield and P uptake.

As demonstrated in Table 2, all the P-fractions viz., Fe-P. Al-P and Ca-P significantly and positively influenced the yield and P uptake at tasseling stage and at harvest. The values of coefficient of correlation 'r' of Fe-P, Al -P, and Ca-P were 0.765*, 0.834* and 0.819* with grain yield and 0.732*, 0.834* and 0.752* with total P uptake at maize harvest.

These findings are online with other workers (Chaudhary, 1991, Chang *et al.* 1990 and Enwezor, 1976).

Relationship of P availability indices with P fractions in soil

Table 3 showed that olsen and citrate souble-P were significantly and positively affected by Fe-P (r=0.762*, r=0.739*), Al-P (r=0. 807, r=0.867*) and Ca-P (r=0.821*, R=0.811*) at wheat sowing.

Similarly olsen and citrate soluble-P at ear formation stage of wheat, maize sowing and tasseling stage had a significantly correlation with different P-fraction at sowing of wheat. Tandon (1987) Minhas and Kick (1977) and Sood and Bhardwaj (1992) also reported similar type of results.

Table 2. Correlation coefficient indicated the relationship of P fractions (at wheat sowing) with growth parameters of wheat and maize

	Wheat Ear Formation		Maize Tasseling		Harvest			
					Wheat		Maize	
Fractions	Dry matter	P uptake	Dry matter	P uptake	Grain	Total P uptake	Grain	Total P uptake
Fe-P	0.736*	0.774*	0.803*	0.773*	0.605	0.758*	0.765*	0.732*
Al-P	0.826*	0.865*	0.767*	0.802*	0.694*	0.857*	0.834*	0.834*
Ca-P	0.753*	0.821*	0.770*	0.832*	0.713*	0.780*	0.819*	0.752*

*Significant at 5% level.

Table 3. Correlation coefficient indicating the relationship between P availability indices and P fractions

	At wheat sowing		
	Fe-P	Al-P	Ca-P
At wheat sowing			
a) Olsen's P	0.762*	0.807*	0.821*
b) Citrate P	0.739*	0.867*	0.811*
At ear formation			
a) Olsen's P	0.757*	0.704*	0.811*
b) Citrate P	0.830*	0.842*	0.862*
At maize sowing			
a) Olsen's P	0.774*	0.877*	0.868*
b) Citrate P	0.467	0.623*	0.582*
At tasseling			
a) Olsen's P	0.643*	0.781*	0.696*
b) Citrate P	0.734*	0.709*	0.749*

*Significant at 5% level

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INFLUENCE OF FERTIGATION WITH MAJOR AND MICRO NUTRIENTS ON NUTRIENT UPTAKE AND YIELD OF GERANIUM (*PELARGONIUM GRAVEOLENS* L. HERITT)

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Rose scented geranium (*Pelargonium graveolens* L. Heritt) is an important essential oil bearing crop, which is valued for its pronounced rose like odor. Since India is not self sufficient in the production of geranium oil it imports this high value essential oil worth Rs. 120.64 tones valuing Rs. 389.03 lakhs per annum (Lawrence, 1999). To reap rich harvests high levels of inputs especially around 200 : 35 : 35 kg per hectare of N, P_2O_5 and K_2O are required (Farooqi, and Khan, 1991). Recent advances in production technology make it possible to apply fertilizer materials through irrigation system viz., drip or sprinkler a practice referred to as fertigation (Bester, *et al.* 1987). One of the important pre-requisites for this system however, is the availability of completely water soluble fertilizers (WSF) which are safe and which do not clog the system. At present such WSF are available only through imports. Studies were conducted on fertigation with main objectives to study the effect of major and micro nutrients on nutrient uptake and yield of Geranium (*Pelargonium graveolens.* L. Heritt).

The field experiment was conducted during 1996-98 at the Horticultural Research station, Gandhi Krishi Vigyan Kendra, Bangalore. Low volume sprinkler system with a discharge capacity of 120 litre/hr was installed in the main experimental field. Two sources of fertilizer viz., normal (urea, single super phosphate and muriate of potash), water soluble fertilizer (WSF) in combination with zinc and boron were used. The recommended dose of fertilizers, 200:35:35 kg/ha N, P_2O_5 and K_2O (Farooqui and Khan, 1991) were given at 60, 80 and 100 per cent of the recommended level. There were 10 treatments with two controls. It means that three crops/ cuts were taken during the period of experimentation. The fertigation treatments were given through the fertilizer tank, which was connected to the main irrigation supply pump. To avoid the drift of water or fertilizer solution in the fertigation treatments, make shift screens were used all along the borders of these plots during imposition of treatments.

At each harvest, the leaf samples were collected and their nutrient content were analyzed as described by (Tandon, 1993). The top 20-25 cm of the crop having more tender twings were harvested at an interval of three months and fresh herbage per hectare was computed based on per plant yields.

The total N uptake and uptake efficiency for six crops of geranium was significantly higher in 80 per cent WSF plus zinc (189 kg/ha and 30.33 percent) with

Table 1. Influence of fertigation with major and micro nutrients on nutrient uptake and yield of Geranium (*Pelargonium graveloens* L. Heritt)

Treatments	Herbage yield kg /plot (10.8 sq. m)	Herbage yield (t/ha)	Nitrogen uptake and uptake efficiency (%)	Phosphorus uptake (kg/ha/yr) and uptake efficiency (%)	Potassium uptake (kg/ha/yr) and uptake efficiency (%)
Control with surface irrigation	55.87	51.74	93.01 (-)	12.56 (-)	52.96 (-)
80% Normal fertilizer+surface irrigation	78.38	69.76	141.54 (30.33)	23.38 (38.64)	83.84 (110.28)
100% Normal fertilizer + surface irrigation	83.58	77.38	165.86 (36.42)	29.09 (47.22)	91.29 (109.51)
Control with sprinkler irrigation	61.50	56.93	113.58 (-)	(15.49 (-)	61.52 (-)
80% Water soluble fertilizer+sprinkler irrigation	75.76	70.14	156.58 (39.59)	26.81 (50.89)	84.95 (114.25)
Water soluble fertilizer+sprinkler irrigation	79.25	73.37	169.66 (38.32)	29.86 (49.42)	92.15 (112.02)
60% Water soluble fertilizer+0.5% zinc+ sprinkler irrigation	66.25	61.71	133.79 (33.98)	17.95 (25.66)	69.32 (77.90)
80% Water soluble fertilizer + 0.5% zinc + sprinkler irrigation	89.08	82.46	188.97 (59.97)	29.74 (61.35)	104.42 (183.78)
60% Water soluble fertilizer + 0.5% boron + sprinkler irrigation	64.86	60.04	131.90 (32.40)	18..24 (27.04)	67.06 (67.14)
80% Water soluble fertilizer + 0.5% boron + sprinkler irrigation	78.01	72.41	162.28 (43.29)	27.32 (52.71)	81.97 (103.60)
F-test	*	*	*	*	*
S. Em±	4.60	3.25	7.28	2.26	4.28
C.D. (P=05)	13.69	9.66	21.63	6.72	12.72
CV(%)	11.04	6.33	8.65	17.00	9.39

sprinkler irrigation. However, it was on par with 100 per cent WSF (170 kg/ha) fertigation. The controls could have low uptake of N as no external and easily available N through fertilizers was made available.

The total P uptake and uptake efficiency for the six crops of geranium was maximum in 80% WSF with Zn (29.74 kg/ha and 61.35 percent). A general discussion on the P utilization per cent would help in assessing the benefit accrued from fertigation especially with WSF. For soil application, water soluble phosphate fertilizers are generally found superior to other forms (Kamath and Sarkar, 1990). But in this experiment, these were not used for soil application, instead they were fertigated on crop canopy through sprinklers thus avoiding loses in the form of leaching and P fixation and lower uptake by soil.

The total K uptake and uptake efficiency in geranium for six crops was significantly higher in 80 per cent WSF with Zn fertigation (104.42 kg/ha/yr and 183.62 percent).

Consequently, the herbage yield increased with the uptake of nutrients. The maximum yields were obtained with 80% WSF + Zn (0.5%) fertigation and 100 per cent NF with surface irrigation (82.46 and 77.38 t/ha) whereas, least yields were obtained in controls (51.74 and 56.92 t/ha) as there was no fertilizer given to them, the lack of nutrition therefore pulled down their yields.

Thus, this investigation indicate the possibility of saving fertilizer use by 20% and improving utilization by geranium efficiently for greater herbage yield. The maximum cumulative and oil yield were recorded with the treatment with 80% WSF + Zn (0.5%) fertigation (82.46 t/ha and 90.70 kg/ha) level. Hence with fertigation, there is not only no fear of leaching losses of nutrients to greater depth but also there is an improvement in fertilizer uptake efficiency, particularly noticeable with WSF.

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EFFECT OF INTEGRATED WEED MANAGEMENT ON ECONOMICS OF SOYBEAN (*GLYCINE MAX* (L.) MERRILL) UNDER *VERTISOLS OF CHHATTISGARH*

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Soybean is mainly grown during *kharif* season in Chhattisgarh. In monsoon season weed infestation is one of the major factors which limits productivity level of soybean crop. It is estimated that the loss in yield of soybean is 30 to 77 per cent due to improper weed management (Chandel and Saxena, 1988). Manual weeding is one of the oldest and most efficient methods of weed control. But unavailability of adequate labourers, their increased wages and declining efficiency under uncongenial conditions (like continuous spell of monsoon) make the tasks more difficult. Under these circumstances, the information on integration of effective and workable weed management practices which can be used ecologically and economically by the farmers is necessary. Keeping in view these facts, the present investigation was under taken to study the effect of FYM and various weed management practices on the economics of soybean cultivation.

The field experiment was conducted during *kharif,* 2001 at Instructional Farm, IGAU, Raipur on black soil (*Vertisols*) having a pH 6.9, available N 220. 14 kg/ha, available P_2O_5 13.60 kg/ha and available K_2O 358.45 kg/ha. The factorial experiment was conducted in randomized block design, consisting of two factors namely organic nutrient (with FYM (5t/ha) and without FYM) and six weed management practices formed in twelve treatment combinations, replicated thrice. Soybean variety "JS-335" was sown at the seed rate of 70 kg/ha in rows 30 cm apart. The crop was grown under rainfed condition. The uniform dose of NPK @ 30:60:20 kg/ha, respectively, applied as basal.

The economic parameters like gross return, net return and cost benefit ratio were worked out treatment wise by using the following formula.

Gross return = Seed x price of seed
Net return = Gross return-Total cost cultivation

$$\text{Benefit cost ratio} = \frac{\text{Net return}}{\text{Total cost of cultivation}}$$

The data on cost of cultivation and economic returns from soybean indicated that maximum total cost of cultivation and gross were recorded under alachlor @ 2 kg/ha + single hand weeding with FYM. The higher cost of cultivation in alachlor @ 2 kg ha^{-1} + single hand weeding with FYM, was mainly due to combined cost of FYM, herbicide and labours. However, net return showed different trend. It was highest in single hand seeding without FYM followed by alachlor @ 2 kg/ha + chlorimuron @4g/ha without FYM. Dubey

Table 1. Seed yield (q/ha) and economics of soybean as influenced by FYM and different weed management pratices

Weed management Practice	Seed yield (q/ha)	Total cost of cultivation (Rs./ha)	Gross return (Rs. ha^{-1})	Net return (Rs./ha)	Additional return (Rs./ha)	Benefit cost ratio (Re../Re.)
Alachlor @ 2 kg/ha	11.25	9734.12	12009.0	2274.88	1141.50	0.23
Chlorimuron @ 4 kg/ha	10.88	9554.12	11855.5	2301.38	1168.0	0.24
Alachlor +chlorimuron @2 kg + 4g/ha	16.35	10214.12	17151.0	6936.88	5803.5	0.68
Hand weeding at 30 DAS	17.24	10354.12	17845.5	7491.38	6358.0	0.72
Alachlor @2 kg/ha+hand weeding at 30 DAS	16.22	11014.12	16779.5	5765.38	4632.0	0.52
Unweeded check	9.37	9074.12	10207.5	1133.38	0.00	0.12
FYM+Chlorimuron@ 4 kg/ha	12.53	10734.12	13584.5	2850.38	5514.5	0.27
FYM+alachlor@ 2 kg/ha +Chlorimuron @ 4 g/ha	13.15	11214.12	13903.0	2688.88	5353.00	0.24
FYM + hand weeding at 30 DAS	16.11	11354.12	16973.0	5618.88	8283.0	0.49
FYM+Alachlor@ 2 kg/ha +hand weeding at 30 DAS	16.90	12014.12	17889.5	5875.38	8539.5	0.49
Unweeded check (with FYM)	6.60	10074.12	7410.00	-2664.12	0.00	-0.26
		-	-	-	-	-
		-	-	-	-	-
C.D. at 5%	2.52	-	-	-	-	-

(1998) also reported similar results. Additional return over control was maximum under alachlor @ 2 kg/ha + hand weeding with FYM followed by single hand weeding with FYM. It might be due to poor performance of unweeded check with FYM. The highest benefit cost ratio was noted in single hand weeding without FYM followed by alachlor @ 2 kg/ha + chlorimuron @ 4 g/ha without FYM (0.68). It might be due to significantly higher seed yield and lower total cost of cultivation. Similar findings were reported by Chandrakar and Urkurkar (1993). The lowest seed yield, gross return, net return and benefit cost ratio were found under unweeded check with FYM.

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EFFECT OF PHOSPHORUS AND SULPHUR ON GROWTH AND YIELD OF COWPEA [*VIGNA UNGUICULATA* (L.) WALP]

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Cowpea (*Vigna unguiculata* (L.) walp) is one of the most dominant pulse crops of arid and semi-arid areas of Rajasthan. It is mainly grown as a *kharif* crop during July-August on the marginal lands. Cowpea (cv. 'RC 19') is a short duration (60 days) crop and its fits well in the cropping sequences. Further the inclusion is known to increase the fertility status of soil. Moreover, there is enough scope for increasing productivity of this crop grown on marginal lands by applying proper amount of phosphorus and sulphur. However, there is a very limited information available on cowpea in this zone. Therefore, an investigation was conducted at S.K.N. College of Agriculture, Jobner, to study the response of cowpea to phosphorus and sulphur under rainfed condition during *kharif* 1992. The treatments consisted of 3 levels of phosphorus (20, 30 and 40 kg P_2O_5/ha) and 5 levels of sulphur (0, 20, 40, 60 and 80 kg S/ha) and were laid out in a randomized block design replicated 3 times. The soil of experimental site was loamy sand in texture with pH 8.2. Diammonium

Table 1. Growth and yield attributes and yield of cowpea as influenced by phosphorus and sulphur levels

Treatment	Plant height (cm)	Pods/ plant	Length of pod (cm)	Seed pod	1000 grain wt.(g)	Grain yield (q/ha)	Straw yield (q/ha)
Phosphorus (P_2O_5 kg/ha)							
20	40.3	10.6	10.5	10.6	72.0	6.9	8.8
30	42.6	11.3	11.9	10.9	72.8	7.8	9.8
40	43.7	12.3	13.3	12.2	74.2	8.9	11.1
C.D. at 5%	0.90	0.88	0.74	1.36	NS	0.83	1.05
Sulphur (kg S/ha)							
0	37.7	9.5	9.7	9.8	72.0	6.6	8.8
20	40.2	10.4	10.6	10.5	72.4	7.1	9.0
40	42.8	11.3	11.9	11.4	73.0	7.8	9.6
60	44.7	12.7	13.3	11.9	73.4	8.4	10.6
80	45.7	13.8	13.9	12.5	74.3	9.4	11.5
C.D. at 5%	1.14	1.14	0.94	1.76	NS	0.67	1.36

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phosphate and gypsum were applied to supply phosphorus and sulphur, respectively as per treatments. The crop was sown in of week of July with inter row spacing of 30 cm using 20 kg/ha seed rate and harvested during last week of September.

All the growth and yield attributes were greatly influenced by the levels of both phosphorus and sulphur. Application of phosphorus @ kg P_2O_5/ha gave significantly higher yield than 20 and 30 kg P_2O_5/ha (Table 1). It resulted in an increase of 28.9 and 15.9 per cent over 20 and 30 kg P_2O_5/ha. Similar trend was also observed in straw yield. This was mainly due to the beneficial effect of this level on all the growth and yield attributes. These results corroborate with the findings of Baboo and Mishra (2001). Further the application of 80 kg S/ha resulted in significantly higher grain yield over rest of sulphur treatments. Application of 40 and 60 kg S/ha also proved significantly superior to control with respect to grain and stover yield. These results are in conformity with the findings of Khandkar and Shinde (1991).

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EFFECT OF LOW DOSE OF SULFONYLUREA HERBICIDES ON WEEDS AND YIELD OF WHEAT (*TRITICUM AESTIVUM)*

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A field experiment having 12 treatments was conducted in randomised block design with three replications in *rabi* 1994-95 at Indian Agricultural Research Institute, New Delhi to study the efficacy of low dose high potent sulfonylurea herbicides on weeds and yield of wheat. The soil was sandy loam, low in organic carbon (0.25%, medium in phosphorus and high in potash with a pH of 8.0. Wheat variety 'Kundan (DL-153-2)' was sown in lines 23 cm apart on 11 November 1994. Herbicides were applied using spray volume of 600 litres//ha with the help of knapsack sprayer fitted with a flat fan nozzle. Nitrogen, phosphorus and potassium were applied @ 50 kg N, 50 kg P_2O_5 and 30 kg K_2O_5/ha, respectively at sowing. Another 50 kg N was applied at 30 days of sowing. The data on total weed count and weed dry weight collected at harvest and subjected to square root transformation before statistical analysis. Individual population of major weed species was also recorded at harvest.

Table 1. Effect of weed control treatments son population of different weed species (No./0.5 sqm) in wheat

Treatments	Dose (g/ha)	*Avena fatua*	*Phalaris minor*	*Melilotus indica*	*Anagallis arvensis*	*Fumaria parviflora*	*Cirsium arvense*
Control	-	6.3	4.0	3.0	3.0	2.6	3.0
Hand weeding	-	1.3	1.0	1.0	1.3	0.3	0.3
Isoproturon	750	4.0	4.0	0.3	2.0	0.0	3.0
Isoproturon	1000	3.3	1.6	0.0	0.3	0.0	2.0
2,4-D	500	3.0	2.3	2.0	1.0	0.0	3.0
2,4-D	750	3.0	3.6	1.6	0.3	0.3	3.0
Metsulfuron-methyl	4	5.0	4.6	0.0	0.6	1.0	0.3
Metsulfuron-methyl	8	5.0	2.0	0.0	0.6	0.6	0.0
Metsulfuron-methyl	12	5.0	4.0	0.3	0.6	0.6	0.0
Terbutron methyl	6	5.0	2.6	0.3	06	1.0	2.0
Terbutron-methyl	12	4.6	3.3	0.3	1.3	0.0	1.6
Terbutron-methyl	18	4.0	2.6	0.0	0.0	0.6	1.6

Table 2. Effect of weed control treatments on weeds, yield attributing characters and yield of wheat

Treatment	Dose (g/ha)	Weed population (No./0.50)	Weed dry wt. (g/0.50 sqm)	No.of tillers/ m^2	1000 grain wt. (g)	No. of grains per ear	Grain yield (q/ha)
Control	-	4.77 (22.)	7.7 (58.60)	109.7	36.83	33.37	39.20
Hand weeding	-	2.37 (5.30)	3.90 (14.80)	148.0	41.97	43.13	53.78
Isoproturon	750	3.80 (14.00)	7.03 (48.80)	120.3	40.90	38.97	50.55
Isoproturon	1000	2.70 (7.00)	5.43 (29.00)	129.0	41.30	39.53	52.00
2,4-D	500	3.30 (10.60)	6.20 (37.90)	121.0	40.87	39.77	49.43
2,4-D	750	3.30 (12.0)	6.20 (44.00)	121.0	40.87	39.77	49.43
Metsulfuron-methyl	4	3.47 (11.60)	6.23 (38.60)	119.7	40.67	38.87	48.46
Metsulfuron-methyl	8	3.10 (9.30)	6.40 (40.60)	123.3	40.63	40.20	48.78
Metsulfuron-methyl	12	3.30 (10.60)	6.73 (45.10)	114.0	40.87	39.03	48.62
Terbutron methyl	6	3.47 (11.60)	5.73 (32.50)	130.7	40.90	40.07	50.88
Terbutron-methyl	12	3.53 (12.00)	5.37 (28.20)	135.6	40.80	39.70	47.80
Terbutron-methyl	18	3.10	6.20	112.0	40.02	39.17	45.39
C.D. at 5%		0.33	1.43	7.5	0.78	1.66	3.81

Values in parenthese are original.

The important weed species that infested the experimental field were *Avena fatua, Phalaris minor, Melilotus indica, Anagallis arvensis, Cirsium arvense* and *Fumaria Parviflora*. All the weed control treatments caused significant reduction in weed population and its dry weight with hand weeding resulting in maximum decrease. Isoproturon at 1000 g/ha and hand weeding caused almost identical decrease in weed population. The former proved ineffective against *Cirsium arvense*. Sulfonylurea herbicides were found more effective against broad leaved weeds (Table 1). Amongst sulfonylurea herbicides, metsulfuron-methyl at 8 g/ha and terbutron-methyl at 18 g/ha brought about similar decrease in total weed population and proved statistically superior to all other treatments except metsulfuron-methyl at 12 g/ha and 2, 4-D at 500 g/ha. Metsulfuron-methyl was found very effective against (*Cirsicum arvense)* (Table 1). Sulfonylurea herbicides are comparatively less effective against grassy weeds especially *Avena fatua and Phalaris minor*. Similar finding was also reported by Pandey and Singh (1995).

All the weed control treatments recorded significant increase in grain yield over uninhibited weed growth (control). Hand weeding brought about maximum increase in grain yield and proved significantly superior to all other treatments except isoproturon 1000 g/ha and terbutron-methyl at 6 g/ha. This was due to adequate weed control and significant increase in attributing characters (Table 2). However, the difference in yield attributing characters amongst herbicidal treatments was found non-significant. In herbicide treatments, isoproturon at 1000g/ha resulted in the highest grain yield but was statistically at par with all other treatments except terbutron-methyl at 12 and 18 g/ha. The latter treatment at 6 g/ha was as effective as other herbicide treatments in increasing the grain yield but its higher dose of application (12 and 18 g/ha) proved detrimental to crop growth and yield. Similar results were also reported by Pandey and Singh (1995).

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CORRIGENDUM

Annals of Agricultural Research, 2002, Volume 23, No. 2, pages 346-348, the authors of the article entitled "Effect of cultural and chemical methods of weed control in Indian mustard (*Brassica juncea*)" may be read as Fateh Singh, B.S. Sinsinwar and O.P. Premi in place of Fateh Singh and B.S. Sinsinwar.

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AN OVERVIEW OF FARMING SYSTEMS RESEARCH IN INDIA

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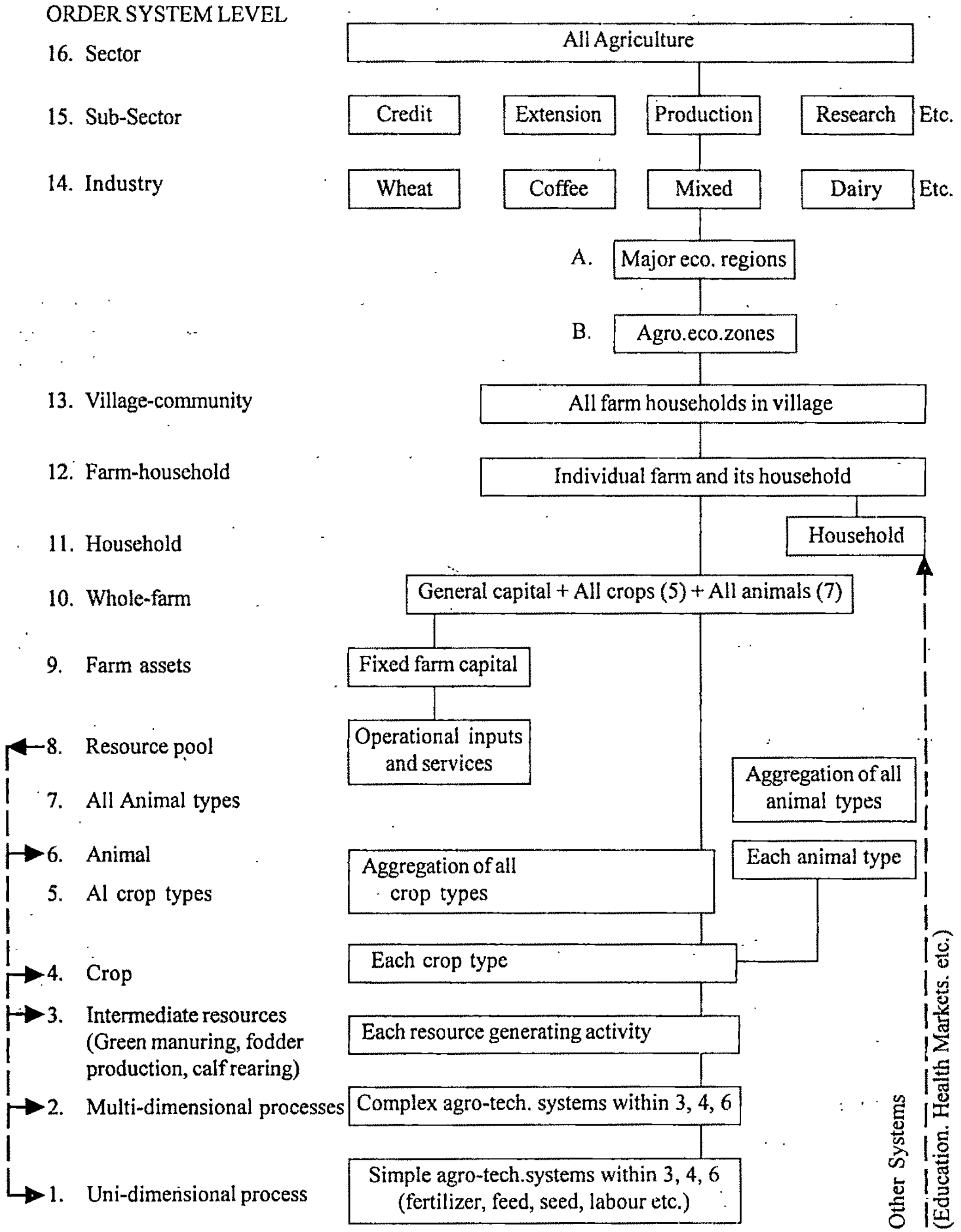
There is consensus that agricultural research must move beyond the boundaries of disciplines, commodities, experimental farms and laboratories, and embrace system perspective (ICAR, 2000). However, despite nearly 30 years of rhetoric, not much headway has been made. Confusion about the concept, apprehension regarding rigour and scientific validity, as well as organizational and operational rigidities perpetuate a status quo. In this paper we briefly introduce the concept of an agricultural and farming system, narrate the Indian experience in this context, and offer some ideas on how to integrate the farming system perspective in the national research system.

An agricultural system is a synthetic (man-made) system, embedded in the natural and social systems. It is defined as "an assemblage of components which are united by some form of interaction and interdependence" (McConnel and Dillon, 1997). A hierarchical classification of agricultural systems, starting from the simplest relationship at the base to the regional, national or even global profile at the apex, is presented in Fig. 1. Each row (order) in the figure has many interacting elements and vertical dependencies. When we intervene at any level or order through technology, institutions, investments, prices (or even when external disturbances like floods, droughts, etc. occur), the final effects on the farmers and the system is mediated through several interactions. Many of these are not factored in when the intervention is planned. Observers of the rural scene can recount many such examples. Naturally, if we plan in a system framework, we plan better.

Fig. 1, also illustrates the complexities and near impossibility of encompassing the totality of the system in any formal structure or model, or experiment. There are too many interactions to handle. That is why elements or components are studied. Policy makers take a regional or sectorial view (order 14,15,16), agro-biological scientists focus on lower orders (order 1, through 7), usually taking one or a feq dimensions at a time. The simplest case is an individual activity-based relationship (like fertilizer response)-order 1, with which we are so familiar. We note that as we go up to the farm level (order 12) the simple relationships established in the lower orders are modified. Thus, tools of analysis and enquiry also change as we move up : more powerful methods (modelling, systems analysis) are needed.

The system view is a very useful conceptual device for everyone concerned with agriculture. It helps researchers in understanding the context of their research and in defining its content, thus contributing


ORDER SYSTEM LEVEL
16. Sector
All Agriculture
15. Sub-Sector
Credit
Extension
Production
Research
Etc.
14. Industry
Wheat
Coffee
Mixed
Dairy
Etc.
A.
Major eco. regions
B.
Agro.eco.zones
13. Village-community
All farm households in village
12. Farm-household
Individual farm and its household
11. Household
Household
10. Whole-farm
General capital + All crops (5) + All animals (7)
9. Farm assets
Fixed farm capital
8. Resource pool
Operational inputs and services
7. All Animal types
Aggregation of all animal types
6. Animal
Each animal type
5. Al crop types
Aggregation of all crop types
4. Crop
Each crop type
3. Intermediate resources (Green manuring, fodder production, calf rearing)
Each resource generating activity
2. Multi-dimensional processes
Complex agro-tech. systems within 3, 4, 6
1. Uni-dimensional process
Simple agro-tech.systems within 3, 4, 6 (fertilizer, feed, seed, labour etc.)
Other Systems
(Education. Health Markets. etc.)

Source : Simplified and adapted from McConnel and Dillon (1997). Other classifications (eg. Fresco and Westphal, 1988) elaborate the same theme.

Fig. 1. The Hierarchy of Agricultural Systems

to its relevance. It helps them see their specialization in perspective and in relation to other forces and creates a better climate for cross-disciplinary work. Agricultural policy and development programmes are better designed if this framework is kept in view.

Farming system :

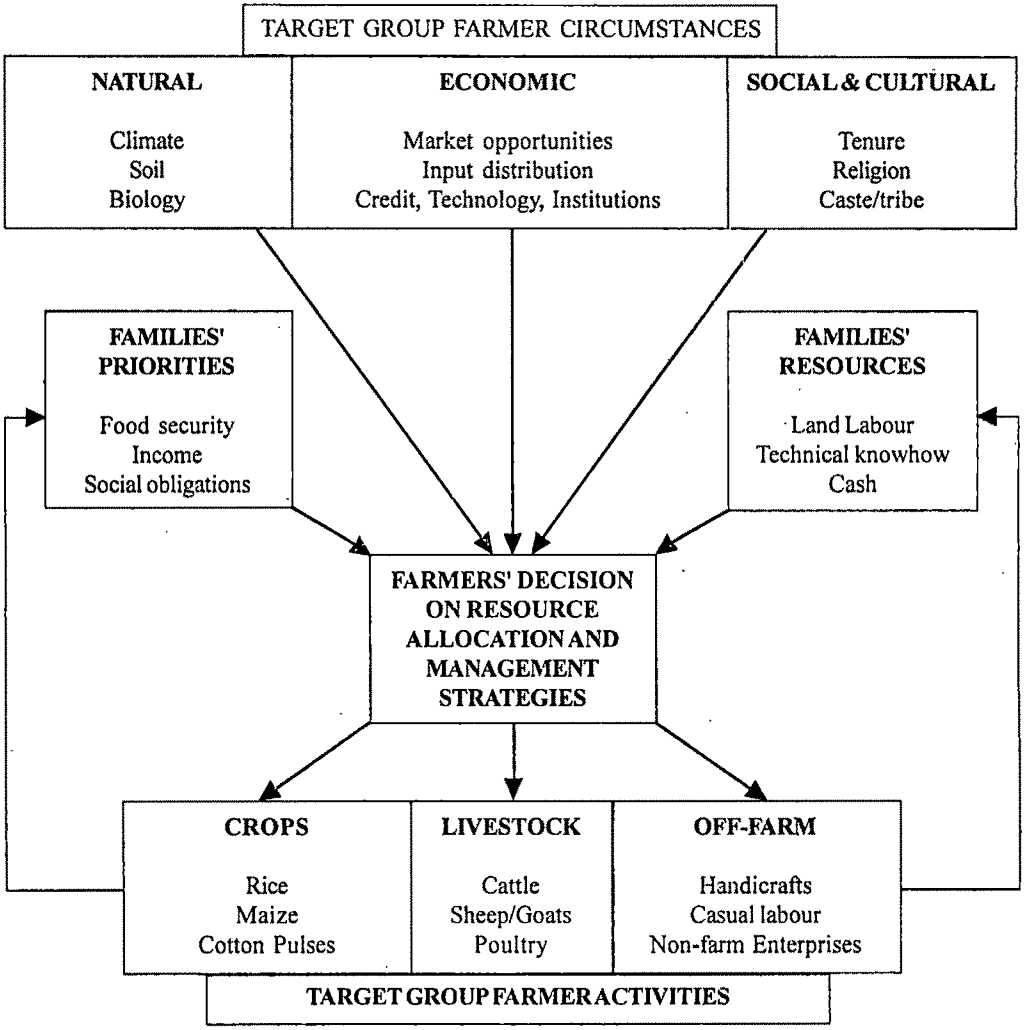
In terms of Fig. 1, a farming system refers to Order 12 or 13. Each farming system represents a fairly homogeneous environment in terms of local circumstances. Farmers face the same problems and opportunities and generally respond similarly. With reference to agricultural technology, there is consensus that the agro-ecological zone (order 14b) should be the target domain. It was so envisaged in the National Agricultural Research Project (NARP). This may include sub-systems-smaller farmers may be different from the larger ones, or, uplands may be different from the valleys (Ghosh, 1991).

The primary inter-relationships at the farming system level are illustrated in Fig. 2. This highly simplified model puts the farmer - the decision maker, at the centre. Decisions are influenced by the priorities of the household, farmer's knowledge and experience, and resources at his command. External factors-natural, economic, and socio-cultural, also play significant roles. On the basis of these, the farmer organizes various activities on his farm. This is the behavioral and decision making component of the system. Each of these linkages or relationships is complex and dynamic. Modellers trying to simulate crop growth, a subordinate component of the farming system (order 4) for example, will vouch for this. This simple model illustrates that all interventions we make to improve the farming system are filtered through this multi-layered sieve and can be aborted at any stage. Lack of appreciation of this perspective has been the bane of most of our agricultural development initiatives, including research. The broker boxes of Fig. 2 - household priorities and decisions, are areas where bio-physical scientists falter. Behavioral scientists too suffer from inadequate understanding of the underlying technical relationships. A farming systems analysis inevitably demands a multidimensional and multi-disciplinary approach.

Farming systems research (FSR) :

Farming systems research is a relatively new concept. The pioneering works of Ruthenburg (1980), Boserup (1965, 1981), and Hayami and Ruttan (1985) illustrated how major farming systems and farming practices evolved in response to the interaction between agro-ecological and human components of settlements. From these originated the idea that by incorporating factors like agro-ecological conditions, relative scarcity of factors of production, and product prices in research planning framework, we can improve the efficiency of applied agricultural research.

Social scientists, mainly agricultural economics, helped develop the idea of Farming System Research (FSR) in the years following the green revolution. Three related factors contributed. First, research in late sixties and early seventies on widely varying pattern of adoption of improved technologies established that farmer's



Source : Collinson, M.P. (1987). Solid boxes are observable, broken ones are deduced from the observed facts or elicited from target farmers

Fig. 2. A Farming System Model

decisions were influenced not only by the technical or even economic superiority of the 'improved' practice but also by a number of other internal and external factors like farmers' resources, infrastructure, price environment, and so on. A view emerged that the agricultural R & D systems in developing countries were generally insensitive to these forces and often made technological recommendations which either ignored these or were in conflict. Such recommendations were, therefore, rejected.

While researchers attributed lack of adoption to extension failure, the 'system' people argued that factors affecting demand for technological options were not taken into account while developing or recommending improved technologies for adoption.

Second, looking at this from the point of view of supply of improved technologies (by the R & D system), questions were raised regarding relevance of research. It was argued that while all applied research must be demand- driven or need-based, the actual research portfolio was often driven by extraneous (and irrelevant) considerations, particularly in centralized systems. No wonder that a large number of research results emanating from such efforts languished. A demand-driven perspective on the other hand, tailors supply to demand for research and weeds out irrelevant research. Farming system scientists contribute to this by objective assessment of biotic, abiotic, and socioeconomic constraints inhibiting system productivity, and prioritizing those which require R & D intervention. Planning research on this basis improves the efficiency of applied research (Byerlee et al. 1991).

Third, the performance of proposed technologies was highly variable over space. This arose from agro-climatic as well as socio-economic variability between and within target domains. The farming systems exponents pleaded for location-specificity.

Since early seventies, research systems in developing countries have responded to these ideas in various ways. Farming system research (FSR) is one of these (Farrington, 1988). International donors, led by the World Bank, enthusiastically supported FSR in the seventies and eighties as an alternative paradigm. In many developing countries of Africa and Latin America, FSR was transplanted almost as an independent research initiative (unit), funded, guided, and often manned by external agencies. The FSR agenda of these units usually involved diagnosis of production constraints, experimentation on farmer's fields to test prospective technical solutions, linking with on-station research if further fine-tuning was needed, assessing the results from a system perspective, and evolving recommendations based on these results, all in a specific target domain (homogeneous zone or farmer group) and with active participation of farmers (Collinson 1987, Norman et al. 1995). Close links between the FSR team, on-station researchers, field extension workers, and the farmers were essential. The CGIAR research centres also created multi-disciplinary FSR units with their own research agendas (Zandstra et al. 1981, ICRISAT 1986). All these provided valuable insights on the constraints and relationships in the system, but success in terms of generating more acceptable technologies was limited and confined to target niches. It was soon realized that replication of this approach systemwide could not be sustained by national resources in most developing countries. The idea of a free-standing FSR unit did not find favour with most national research systems. Donor interest also waned gradually (Merrill-Sands 1988). It has been shown that the organizational, managerial, and policy pre-conditions for effective on-farm-client oriented research are not easy to institutionalize even in national research systems which have a long tradition of FSR (Merrill-Sands et al. (1991). A mental block against downstream, development-oriented research which is considered less prestigious and rewarding, continues to dominate. There was also an apprehension, particularly in large systems (rarely made explicit), that putting most of limited research resources in this mode would hurt upstream research which generates breakthroughs. The Indian agricultural research system, led by ICAR, never opted for a free-standing system though it has experimented with several related approaches. These are briefly reviewed in the next section.

Nevertheless, FSR experiences influenced research systems in significant ways and several ideas emerging therefrom are gradually being integrated in mainstream agricultural research (Low and Wadding on, 1991; also Byerlee and Tripp, 1988; Spencer, 1991; Maurya et al. 1988). Reforms being attempted in national research systems (National Agricultural Technology Project - NATP) emphasis these lessons (ICAR 1998). Important among these are the following :

First, there is increased emphasis on farmers' participation in the research process. On-farm adaptive and verification trials are now increasingly becoming a part of the research process. Scientists are experimenting with farmer participatory research design and evaluation. Farmers and indigenous practices have gained the respect of scientists (Chambers et al, 1989); historically, they were perceived as traditional, inefficient and passive.

Second, the focus in research is gradually shifting from component to system. Every research unit emphasizes this and tries to incorporate it in research design. The system perspective is gaining a foothold, even in disciplinary research, imparting greater relevance.

Third, work on farming systems has brought the issue of research relevance to the fore. Ideas like need-based, demand-driven research are increasingly being invoked in developing research programmes. Themes like tackling biotic and abiotic production constraints, meeting cropping system needs, exploiting market opportunities, supplementing household fuel and fodder stocks, etc. are now more frequently encountered in research agenda.

Fourth, the idea of focussing research on well-defined research domains and location-specificity is now well accepted. It is a significant departure from the past when research programmes concentrated largely on activities like crop, livestock, irrigation, etc. in a sectorial way and sought to develop widely adaptable technologies. One must, however, note that ground realities in terms of availability of infrastructure and scientific manpower at decentralized levels dempens this enthusiasm.

Finally, most national systems have started creating strength in economics and other social sciences. These have been major players in development of farming systems work. Increasing involvement of economists and sociologists in agricultural research provides better assessment of research needs, priorities and impact.

To sum up, farming systems or on-farm client-oriented research is closer to the 'development' end of the R & D process. It is location-specific and demands effective linkages not only with the target group of farmers but also with other forces, entities (institutions and organizations) influencing their decisions. In most developing countries the problem is that there is no effective farmer or rural lobby to articulate their needs (constraints), nor are product and factor markets developed enough to play this role. The research systems have evolved in a top-down manner, emulating the disciplinary dispensation of western science. The structure, organization, modalities and even methods have developed in this mode. Over the last thirty years or so, FSR has provided an alternative, and we have tried different forms of adaptation. In general, however, the system has not been proactive in encouraging these through proper organizational or incentive and reward signals (Merrill-sands et al. 1989, 1991). This is paradoxical because all stated pronouncements emanating from the top extol the merits of the system approach (ICAR 2000).

Review of Indian experience

The classical FSR model did not find favour with the Indian research system. It was basking in the glory of green revolution and had set its goals in terms of various other revolutions through a similar methodology. This premise shaped the growth of the NARS in the seventies and eighties and continues to dominate even today. Nevertheless, within this top-down and supply-driven framework, several FSR ideas have been incorporated. The following paragraphs provide a broad overview.

(1) The national extension system created in the fifties was designed to empower the farmers with new technical information and sensitize the researchers regarding the needs of the clients. This was a grand farming system design. However, over time it evolved as a one-way (research → extension → farmer) chain (Rasheed and Hall, 2002). The research arm believed that it knew what the researchable problems were and that it had many improved techniques on the shelf which just needed to be conveyed to farmers. That was the job of the extension service. Thanks to the success of green revolution, this paradigm was entrenched : it still persists, though somewhat discredited. Over the last decade or so, the extension service has started feeling the accountability pressure - it never had a research constituency, its credibility with the farmers also eroded. The research = extension = farmer model to instil farming (client) realities in the technology system did not work; the forward linkage weakened and the backward linkage did not develop, even after T & V.

As this 'transfer of technology stress' evolved, the research system, particularly the ICAR, tried a more aggressive stance. It initiated National Demonstrations, Krishi Vigyan Kendras, and other programmes which brought research-backed professionals and farmers in direct contact. A supply-driven 'transfer of technology' programme called frontline extension emerged as ICAR's answer to conventional extension. To the extent these brought researchers and farmers together, bits of the 'system' did get rubbed off and we started getting system related questions from specialists like plant breeders, agronomists, etc. This trend is growing and the system perspective is making inroads in the NARS.

(2) The research system emphasized upgrading the quality of TOT by entrusting it to scientists. All programmes of the extension division of ICAR - National Demonstrations, Operational Research Programme, Lab to Land, KVKs, IVLP, are in this mould. The technology net was sprung wider in terms of commodities and resources, providing more diversified options to meet varying needs of farmers. This brought in another system attribute. All these programmes implicitly recognized that improved technologies need to be evaluated and refined in context of real world situation of target farmers. These come closest to FSR in the ICAR and try to establish a demand - or need-based research paradigm. Unfortunately, these programmes have actually been implemented as upscaled demonstrations with little evidence of effective feedback. Lack of conviction regarding scientific credibility of this approach is also revealed by the fact that these initiatives have been placed under the Division of Extension in the Council and not in the hard-core research divisions. In retrospect, the ICAR extension programmes undermined the evolution and integration of FSR in mainstream agricultural research. The latter needed substantive change, the former could be easily added on.

(3) Agronomists have been the first among agricultural scientists to initiate work on farmers' fields Simple Fertilizer Trials were started in the fifties in response to the need to develop more relevant recommendations. In late sixties, the basic idea was extended in the Model Agronomy Scheme to other improved techniques (varieties, irrigation, etc.) developed on research stations. This preceded articulation of the FSR idea.

(4) Intensification and multiple cropping expanded the domain of on-farm experimentation further and a focus on potential productivity of the most limiting resource, land, emerged. From individual crops, we started talking about crop combinations and crop rotations; profitability and sustainability concerns began to be incorporated (Jha, 2001). Because testing on farmers' fields in various agro-ecological situations was an integral part of this approach, this was called cropping systems research. The new name and creation of a separate research unit, Project Directorate of Cropping Systems Research (PDCSR), was coterminous.

(5) Over the last decade or so, the PDCSR has taken additional steps in the 'system's direction - decentralizing choice of technologies as well as crops to be tested in various situations, incorporation of economic dimensions, fodder and fuel needs etc in evaluating results, diagnostic studies to make the trials more relevant, etc are examples of farming systems ideas being incorporated in mainstream research.

(6) An attempt has been made to infuse the on-farm testing and verification idea system wide under NATP-supported production systems research. This framework includes, at least conceptually, a feedback and refinement role at the experiment station, and the total process is put under the rubric of production system

research. This is path breaking in that it expands the domain of research into what has traditionally been extension territory. We need to watch how this initiatives fares.

(7) FSR works at local levels and can not be implemented in a centralized system. Leaders of our research recognized this and with World Bank help created basic research infrastructure in more than 120 agro-ecological zones of the country to undertake need based, mostly adaptive, research in close collaboration with client groups. Nearly 25 years later, this vision and the bold Indian experiment with farming systems research has vanished. The zonal research stations created under NARP have an altogether different (and dilapidated) look now.

(8) The enthusiasts amongst us have tried another version of farming system research, trying to sijulate a multi-enterprise farm at the experiment station involving a combination of crops, animals, fish agro-forestry, etc. There is hardly a research component in this. What is attempted is simply trying to demonstrate how best practices for different enterprises could generate higher incomes as compared to what farmers are getting.

(9) Farmer participatory research is another idea being tried at a few locations in the country (Witcombe et al., 2002: Eyzaguirre and Iwanaga, 1996). This takes research to farmers'-they decide what improvements they want and participate in assessing various options based on their choice criteria. The job of the researchers si to understand and codify expressed needs of the farmers, present and demonstrate to them a cafeteria of relevant options, and ascertain whether or not there is one which meets what the farmers need. They may draw a blank in which case the problem goes back to the drawing board at the experiment station for further research.

(10) Modeling-based system research also holds promise as a predictive and simulation tool. In the Indian context, most such work by agricultural scientists has focussed on individual activity (crop growth, input efficiency) and not on farm modeling. Agricultural economists have done a little better with programming models at the farm level. Most of these deal with the potential created by improved production technology (Singh et al., 2001) but generally abstract from detailed technical interrelationships. This approach is under utilized.

(11) Finally, a number of grassroot level initiatives by voluntary groups and non-governmental organizations are also cast in a system mode, though it is usually not made explicit. So, a beginning with production thrust quickly extends to credit, marketing, input distribution, and other areas. Unfortunately, these experiences are not systematically analyzed or synthesized to draw replicable lessons.

This brief review of the Indian experience with FSR version components of different hues tells us about the confusing state of matters. The latest policy pronouncements (ICAR, 1998, 2000) borrow the rhetoric of FSR liberally. The intention perhaps is to internalize FSR concepts within the existing research edifice. There is, however, no blueprint to affect this. We take it up later.

The agricultural research system has not explicitly adopted the FSR framework, even though some ideas have filtered in. As we have shown, the conventional FSR is relevant for well-specified (and small) target domains. The ICAR is concerned with the national perspective and is not mandated to operate at this level. Yet there is pressure to demonstrate results at field level. That is why there is frontline extension. The SAU (and ZRS under them) would find the approach most relevant and useful, but inertia, institutional rigidities, dominance of disciplinary-orientation, and lack of funds constrain them.

Approach to Farming Systems Research : Suggestions

1. Experience over the last three decades reveals two major evolutionary strands. One is a pervasive farming perspective which is relevant for all agricultural research. Instilling this perspective systemwide is essential for improving the relevance and productivity of the NARS. (Byerlee and Tripp 1988; Zeigler 1986). This requires intensive and structural linkages between specialists, between them and farmers in different target domains. The commodity research units, coordinated projects and main stations of SAU need to build this component in their research programmes and budgets. Presently, the task is assigned to extension with reluctant participation of a few junior scientists. Fostering and supporting these linkages in the research arm should be a priority for the ICAR.

2. The other dimension is the classical FSR model involving diagnostic surveys and field experimentation in a target domain with intensive involvement of farmers, extension services and other agencies. This, despite conceptual elegance, has suffered from several infirmities such as ambiguities in concept (Merrill-Sands 1986), isolation from mainstream research, inexperienced personnel, inadequate incentives, etc. These need to be addressed and the ZRS should emerge not only as main centres for technology refinement and testing but also as determinants of research agenda at higher levels. Unfortunately, state funds are in such disarray that this revival cannot stem from there. Once again the responsibility would fall on ICAR. A significant portion of future incremental funds should be so directed. This will also translate the rhetoric of decentralization into reality.

3. Another thing which needs to be done on priority basis is delimitation of target domains. Even though we had a consensus on NARP zones, every research unit/ programme of ICAR uses its own target zones. It may be logical but there is a need to dovetail these and to undertake intensive diagnostic surveys in FSR mode (Byerlee et al. 1991). An institution like PDCSR should coordinate this activity which will be a system wide effort.

4. Specialists with FSR perspective will have to be trained. For this farming systems ideology and principles should be integrated in degree programmes in universities and leading research centres (Tripp and Woolley 1990). This will sensitize specialists. Those who are involved in on-farm research will need to be trained in social science skills.

5. In addition, there is need for a systematic and genetic initiative on farming systems.

ICAR should create a Systems Research and Training Institute (SRTI). The agenda of the institute should be (a) to undertake delimitation of farming systems prevalent in the country and validate NARP zones; (b) to initiate studies in collaboration with local institutions to understand different systems, sub-systems and their constraints, (c) to refine and develop methodologies for FSR, (d) to undertake modelling and system simulations at various levels for assessment, evaluation of prospective technological or other interventions (Harrison et al. 1990) and (e) undertake training in FSR methodologies, systems analysis and its application in agriculture.

As agricultural research was initiated nearly a century ago, leaders of the system were clear that ideas for research must originate from farmer's fields. In the period after Independence, under the influence of agricultural development experience in the West, developments in science became the major source of research ideas. In this supply-driven framework, farmers and farming systems were pushed to the background. Poor countries suffered most from this. This bias must be addressed. Systems research in generation and farming system research in particular offer opportunities in this regard leading to a new agricultural research paradigm.

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VARIABILITY STUDIES IN SEGREGATING POPULATIONS OF RICE

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ABSTRACT

Genetic parameters were studied in a set of seven parental lines and their 21 F_2 populations in rice. Among the characters studied, grain weight/panicle, yield/plant and grains/panicle had high heritability and genetic advance suggesting that improvement for these characters could be brought about by direct selection. Days to flowering, maturity, tillers/plant and panicle length exhibited high heritability but low genetic advance suggesting that selection for these characters must be taken up in advance generations.

Key words : Variability, rice, genetic parameters.

Attempts are being made to widen the variability and for the evaluation of high yielding varieties by resorting to hybridization. Economic characters, mostly polygenically controlled and having complex inheritance are often influenced by environment. Hence, progress in breeding in determined by the magnitude and nature of their genotypic variability. The study of genetic variability in the segregating generations from where the actual selection is made may be more useful to the breeder. The present study was undertaken to evaluate 21 F_2 progenies of rice to assess the magnitude of variability and to understand the heritable component of variation.

MATERIALS AND METHODS

Twenty one F_2 populations of rice alongwith their seven parental genotypes namely, Vikas, Jaya, Chambal, IR-64, BK-79, IR-36 and Annapurna were planted in a randomized block design replicated thrice with a spacing of 20×15 cm between rows and plants. Ten plants from parental lines and 20 plants from F_2 were randomly selected from each plot and each replication for recording observation on days to flowering, days to maturity, tillers/plant, panicle length, grains/panicle, grain weight/ panicle, 100-grain weight and yield/plant. The genotypic and phenotypic co-efficient of variability, heritability (broadsense) and genetic advance were computed (Singh and Chaudhary, 1985).

RESULTS AND DISCUSSION

Data on mean, variability, heritability and genetic advance are presented separately for parents and F_2 progenies in Tables 1 and 2.

Since variances are associated with units, phenotypic coefficient of variation

Table 1. Mean, coefficient of variability, heritability (broad sense), genetic advance and genetic advance % of mean for yield and related characters in parental lines of rice

Character	Mean	Variance		Coefficient of variation (%)		Heritability	Genetic	Genetic advance
		Genotypic	Phenotypic	Genotypic	Phenotypic	(%)	advance	as % of mean
Days to flowering	104.14	146.08	147.03	11.61	11.64	99.36	24.81	23.83
Days to maturity	133.28	114.09	115.19	8.01	8.05	99.05	21.89	16.43
Tillers/plant (no.)	11.74	0.31	1.64	4.75	10.90	18.99	0.50	4.26
Panicle length (cm)	24.50	2.07	2.12	5.87	5.94	97.53	2.92	11.95
Grains/panicle (no.)	155.56	744.22	775.51	17.53	17.90	95.97	55.05	35.38
Grain weight/panicle (g)	3.41	0.91	0.93	27.91	28.21	97.90	1.94	56.89
100-grain weight (g)	2.43	0.10	0.10	13.08	13.11	99.45	0.65	26.87
Yield/plant (g)	20.80	24.91	28.91	23.98	25.83	86.18	9.54	45.86

Table 2. Mean, coefficient of variability, heritability, (broad sense), genetic advance and genetic advance as % of mean for yield and related characters in parental lines of rice in F_2 population of rice

Character	Mean	Variance		Coefficient of variation (%)		Heritability	Genetic	Genetic advance
		Genotypic	Phenotypic	Genotypic	Phenotypic	(%)	advance	as % of mean
Days to flowering	101.58	53.73	54.16	7.21	7.24	99.19	15.04	14.80
Days to maturity	131.46	44.56	45.00	5.07	5.10	99.02	13.68	10.41
Tillers/plant (no.)	12.51	1.34	1.66	9.26	10.31	80.64	2.14	17.41
Panicle length (cm)	24.88	2.23	2.29	6.01	6.07	97.17	3.04	12.24
Grains/panicle (no.)	162.29	635.44	641.99	15.53	15.61	98.98	51.66	31.83
Grain weight/panicle (g)	3.23	0.34	0.34	18.07	18.18	98.94	1.19	37.04
100-grain weight (g)	2.45	0.05	0.05	9.40	9.49	97.99	0.47	19.16
Yield/plant (g)	19.36	12.37	12.98	18.16	16.81	95.30	7.07	36.54

(PCV) and genotypic coefficient of variation (GCV) would be more precise for discussion. Among parents, PCV was highest for grain weight/panicle (28.21) followed by yield/plant (25.83). The GCV was maximum for grain weight/panicle (27.91) and yield/plant (23.98). In F_2 progenies, maximum PCV was observed for yield/plant (18.61) followed by grain weight/panicle (18.18). Highest GCV was also obtained for yield/plant (18.16) followed by grain weight/panicle (18.07). The magnitude of variation in F_2 for these characters might be due to genetic recombination. A comparison of PCV and GCV estimates between parents and F_2 population showed much differences in respect of most of the characters indicating environmental influence.

Heritability was high for all the characters in both the populations except tillers/plant in parental lines (Tables 1 and 2). Heritability in broadsense includes additive and epistatic gene effect, and hence it will be reliable only if accompanied by high genetic advance. Johnson *et al.* (1955) pointed out that without genetic advance, the estimates of genetic heritability will not be off much value for selection on phenotypic performance, they suggested that genetic gain should also be considered alongwith heritability estimates. Grain weight/panicle (56.89%) and yield/plant (45.86%) showed high genetic advance expressed as per of mean in parents and in F_2 populations, it was 37.04% and 36.54% for grain weight/Panicle and yield/plant, respectively. Low genetic advance in both the populations was obtained for days to flowering, maturity, tillers/plant and panicle length, while moderate genetic advance was noted for 100-grain weight. Tripathi *et al.* (1973) obtained similar results for weight/panicle and high heritability with low genetic advance for days to flowering, maturity, panicle length and panicle/m^2 in rice.

An overall consideration of results revealed that grain yield could be improved through selection for weight/panicle, grains/panicle and 100 grain weight. Days to flowering and maturity and panicle length had high heritability but comparatively low genetic advance as per cent of mean and therefore, selection for these characters will have to be carried in advance segregating generations.

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MEIOTIC STABILITY OF DURUM STRAINS DERIVED FROM *TRITICUM DURUM X T. TIMOPHEEVI* CROSSES

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ABSTRACT

Meiotic stability and pollen stainability were studied in 45 durum strains derived from *Triticum durum* × *T. timopheevi* crosses, and their 4 durum parents. Out of 34 BC_2 derivatives from tenth generation of selfing, none segregated for any phenotypic trait, however, presence of univalents in 20% emphasized the importance of meiotic screening of interspecific derivatives. Despite five generations of selfing of nine BC_2 derivatives, 44% were either segregating for phenotypic traits, or showed spike sterility, or even univalent formations leading to their instability at the genic level. It could be deduced that timopheevi introgressed derivatives take more generations of selfing to stablize. Eight derivatives carrying univalents also showed high pollen stainability revealing thereby that stainability of pollen does not give any definite indication of meiotic instability.

Key words : *Triticum durum, T. timopheevi*, meiosis, interspecific hybridization, pollen stainability, univalents, recurrent selection, sterility

Due to increasing demand for durum wheat production and products, breeding efforts to evolve high yielding durum strains with considerable stability level is of the utmost importance. However, Indian durums have a very narrow genetic base for agronomic characters and disease resistance (Agarwal and Pandey, 1978). To diversify their genetic base, work is in progress to infuse genes from different *Triticum species* and *Triticum timopheevi* is one of them.

Although interspecific crosses bring in undesirable genes, their advantages in terms of high yield, improved quality and disease resistance are well acknowledged (Baum *et al.*, 1992). *Triticum timopheevi* is known for its high protein, sedimentation value and 1000-grain weight (Pandey and Rao, 1987). In transferring desirable traits from *Triticum timopheevi* to *Triticum durum*, sterility of the F1 has been a problem. Patil and Deodikar (1983) reported that it is impossible to overcome the sterility of F_1 hybrid between *Triticum durum* × *T. timopheevi* through durum back crosses and suggested the use of *T. dicoccum* as a bridging species. But by making use of high atmospheric temperature, Pandey and Rao (1983) could produce back cross derivatives of durum

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using durum as the recurrent parent.

Genomic differences between *Triticum durum* (AABB) and *Triticum timopheevi* (AAGG) create problems in developing pure breeding and stable lines of durum from *Triticum durum* × *T. tiopheevi* crosses. Meiotic stability of genotypes is essential to get stable performance year after year. Cytological instability of genotypes may be one of the factors responsible for the deterioration in their yielding ability and becoming susceptible to diseases. So, it is desirable to breed varieties which are cytologically stable (Singh and Joshi, 1974). The present investigations were, thus, made to study the meiotic behaviour of the durum strains derived through interspecific crosses with *Triticum timopheevi*.

MATERIALS AND METHODS

Experimental materials for the study comprised of 45 semi-dwarf true breeding introgressed durum derivatives derived from *Triticum durum* × *T. timopheevi* crosses, and their 4 durum parents (Table 1). All the 49 genotypes were sown in 2 rows each, 5 m long and 23 cm apart at the experimental farm of the Indian Agricultural Research Institute, New Delhi. The crop was raised under good fertility coditions using N : P : K @ 120 : 60 : 40 kg/ha. Meiotic and pollen stainability studies were undertaken as per the following procedures :

Meiosis

Young spikes at the appropriate stage of meiosis were collected in the morning. One anther from each spikelet was systematically tested for the presence of first meiotic metaphase. The remaining 2 anthers were fixed in 3 : 1 mixture of absolute alcohol and glacial acetic acid and stored in the fixative for atleast 3 hours. The fixed anthers were hydrolyzed in 1 N HCl at 60°C for 12 minutes and then stained in leucobasic fuchsin solution. The well stained anthers were smeared on slides in 2% acetocarmine and minimum of 15 pollen mother cells (PMC) were analyzed for pairing and occurrence of meiotic abnormalities at first meiotic metaphase. Occurrence of univalents were considered meiotic abnormalities. Observations were made on number of univalents and bivalents (ring and rod). Means and standard errors were calculated following standard statistical procedures.

Pollen stainability

Pollen grains from ready - to - dehisce anthers were mounted in a drop of 2% acetocarmine and observed under the microscope. Deeply stained pollen grains showing normal size and shape under five different microscopic fields were counted for the calculation of per cent pollen stainability as the ratio of number of stained pollen grains to the total number of pollen grains to the total number of pollen grains under a microscopic field.

RESULTS AND DISCUSSION

Experimental results on meiotic and pollen stainability analysis of the derivatives and parents are presented in Table 1. Out of 45 derivatives analysed for meiotic behaviour, eight, B 189, B 203, B 207, B 213, B 225, B 229, B 232 and B 1553 showed mean univalents per cell ranging from 0.11 (B 1553) to 0.86 (B 213). The remaining 37 derivatives and the 4 durum parents were stable in their meiotic behaviour as they showed invariably 14 bivalents at metaphase I without any indications of meiotic abnormality in the form of univalents. However, the number of ring and rod bivalents per pollen mother cell varied considerably between 12.74 - 13.88 and 0.14 - 1.26, respectively. The number of rod bivalents per PMC was greater than or equal to one in 13 derivatives. This may be attributed to the fact that the back cross progenies may contain complete chromosome arms from *T. timopheevi* substituting their homologue in *T. durum*. Such partial chromosome substitutions may become doubled and homozygous in successive generations. If desired genes are located in the G. genome of *T. timopheevi*, possibilities for transfer are proportionate to the extent of allosyndetic pairing of G. chromosomes with their partial homologues either in A or B sets or *T. durum* leading to gene exchanges in such allosyndetic pairs. Similar results were obtained by Chopde adn Deodikar (1964) in hybrid and back crosses of *T. timopheevi* with *T. dicoccum*. The meiotic irregularities may arise from partial asynapsis or desynapsis as Wagenaar (1961) established the presence of asynaptic gene (s) in *timopheevi*, which controlled the pairing behaviour of chromosomes of B and G genomes. These modes of behaviour are known to be influenced by environmental conditions and genetic factors as well as also reported by Maan and Mc Cracken (1968 and 1969) in *T. aestivum* × *T. timopheevi* crosses.

The occurrence of high frequency of rod bivalents ($\geq$1/cell) may be attributed to a very meagre residual homology due to gene transfers from *T. timopheevi* (AAGG) to *T. durum* (AABB) or it may be due to the influence of environment. However, occurrence of such rod bivalents will not cause meiotic irregularities in derivatives leading to their deterioration. DWL 5023 being the most stable variety also exhibited the presence of rod bivalents to the extent of 0.73/cell. DWL 5023 gave highest restoration of fertility in sterile *T. durum* × *T. timopheevi* hybrids (Pandey and Rao, 1984, Pandey *et al.*, 1990). In a study of *T. durum* and *T. aestivum* varieties, El-Today *et al.* (1971) observed that a small portion of meiotic irregularities in the form of univalents, lagging chromosomes, false bridges and micronuclei affect neither the species stability nor the high percentage of seed setting. Similarly, Ibragimova (1983) observed that meiotic disturbances in the form of micronuclei increased at lower temperature while on the contrary, Reddy (1992) found increased frequency of univalents, rod bivalents, laggards and micro nuclei at higher temperature in barley, triticale, bread wheat and durum wheat varieties. Pollen stainability was studied at lower (20.2°C) and higher (25.3°C) temperatures (Table 1) in the field. Mean pollen staibability in the four check varieties ranged from 96.07% (DWL 5023) to 97.70% (Raj 1555) at the lower temperature, whereas at higher temperature the range was 96.37 (Raj 1555) to 99.28% (PBW 34). Except Raj 1555, all the check varieties showed higher percentages of pollen stainability at high temperature than at lower. Pollen stainability percentages in 45 derivatives ranged from 79.66% (B 213) to 98.15% (B 219) at lower temperature and from 85.20% (B 459) to 99.21% (B 212) at higher temperature. B 194 and B 469 showed low stainability of 87.34% and 85.20%, respectively, at higher temperature than at lower (90.65% and 96.35%, respectively) indicating their sensitivity to high temperature. In the remaining derivatives, the stainability percentages were comparatively higher at high temperature than at lower, except in B 187, B 188, B 200, B 207, B 217, B 218, B 219, B 221, B 231, B 459 and B 1553 which showed similar pollen stainability at both the temperatures. Two derivatives, B 203 and B 557, showed very high spikelet sterility at flowering while B 495 and B 518 segregated for certain traits.

High pollen staibability of durum parents, compared to most of the derivatives (Table 1) revealed that *T. timopheevi* blood continues to have its impact on pollen behaviour of the derived lines. Comparatively higher stainability in most of the genotypes at higher temperature but low stainability in two derivatives B 194 and B 469 evidenced that these two strains showed sensitivity to high temperature leading to certain degree of pollen sterility in them. Similarly, low stainability of B 190 and B 208 at lower temperature showed that like sterility of female gametes of *T. durum* × *T. timopheevi* hybrids at low temperature (Pandey and Rao, 1984, Pandey *et al.* 1990), these two derivatives are also sensitive to lower temperature like their hybrids. However, B 203 and B 557 having high visual sterility showed high pollen stainability also and hence, pollen stainability does not appear to be reliable guide of degree of sterility of derivatives as also observed by Grigor'eva and Shcheblyakova (1988). Eight derivatives, B 189, B 203, B 207, B 213, B 225, B 229, B 232 and B 1553 carrying univalents also showed high pollen stainability revealing thereby that stainability of pollen does not give any definite indication of meiotic instability.

It is important to mention that out of nine derivatives from fifth generation of selfing, four, B 495, B 518, B 557 and B 1553, were either segregating or showed spike sterility or even univalent formations leading to their instability at the genic level. Of the 34 derivatives studied from tenth generation of selfing, seven showed the presence of univalents. So it could be deduced that *T. timopheevi* derivatives take longer generations of selfing to stabilize as 44% derivatives from fifth generation of selfing showed instability compared to 20% from tenth generation of selfing. Lapochkina *et al.* (1984) have also observed meiotic instabiloity in advance generations (F_5) of *T. spelta* × *T. durum* crosses. Despite five generations of selfing of nine BC_2 derivatives, presence of univalents and other genic instability in nearly 44% of them suggested that these derivatives need further selfing and selection to make them meiotically stable and breed true. Evidently, of the 34 BC_2 derivatives from tenth generation of selfing, none segregated for any phenotypic trait. However, presence of univalents in nearly 20% derivatives emphasized the importance of meiotic screening of interspecific derivatives before putting them on intensive yield testing.

Occurrence of meiotic irregularities in certain interspecific derivatives even after long generations of selfing could be due to the presence of macro chromosome segmental heterogeniety in the derived genotype. Since the majority of the lines are

Table 1. Meiotic and pollen stainability analysis of the durum parents and derivatives

Variety/ Strain	Number of selfing	Number of bivalents/cell		Number of univalents/cell	Pollen stainability (%)		Remarks
		Ring	Rod		Lower temp. (20.2oC)	Higher temp. (25oC)	
Durum Parents							
PBW 34		13.70±0.15	0.30±0.15	–	96.82	99.28	
Raj 1555		13.55±0.21	0.45±0.21	–	97.70	96.37	
HD 4502		13.58±1.19	0.42±0.19	–	96.58	98.43	
DWL 5023		13.27±0.24	0.73±0.24	–	96.07	97.18	
Derivatives							
B 187	$BC_2 S_{10}$	13.43±0.20	0.57±0.20	–	97.92	98.63	
B 188	$BC_2 S_{10}$	12.80±0.25	1.20±0.25	–	93.58	92.94	
B 189	$BC_2 S_{10}$	12.89±0.35	1.00±0.29	0.22±0.22	93.39	95.94	
B 190	$BC_2 S_{10}$	13.18±0.21	0.82±0.21	–	84.03	95.00	
B 191	$BC_2 S_{10}$	13.75±0.16	0.25±0.16	–	95.34	97.01	
B 193	$BC_2 S_{10}$	13.12±0.23	0.88±0.23	–	91.53	93.36	
B 194	$BC_2 S_{10}$	13.71±0.18	0.29±0.18	–	90.65	87.34	
B 200	$BC_2 S_{10}$	13.37±0.26	0.63±0.26	–	96.25	95.94	
B 201	$BC_2 S_{10}$	13.20±0.30	0.80±0.30	–	93.60	95.88	
B 202	$BC_2 S_{10}$	12.86±0.46	1.14±0.46	–	92.60	99.09	
B 203	$BC_2 S_{10}$	12.78±0.15	1.00±0.24	0.44±0.29	96.26	98.73	highly sterile
B 207	$BC_2 S_{10}$	13.13±0.0	0.62±0.25	0.50±0.33	96.62	95.32	
B 208	$BC_2 S_{10}$	13.57±0.17	0.43±0.17	–	87.40	93.22	
B 209	$BC_2 S_{10}$	13.12±0.13	0.88±0.13	–	93.78	97.60	
B 210	$BC_2 S_{10}$	13.37±0.26	0.63±0.26	–	95.78	98.71	
B 212	$BC_2 S_{10}$	13.44±0.18	0.56±0.18	–	91.50	99.21	
B 213	$BC_2 S_{10}$	13.00±0.31	0.57±0.34	0.86±0.40	79.66	93.67	
B 216	$BC_2 S_{10}$	13.86±0.10	0.14±0.10	–	90.87	98.83	
B 217	$BC_2 S_{10}$	13.40±0.27	0.60±0.27	–	95.61	95.47	

contd...

Table 1 contd...

B218	$BC_2 S_{10}$	12.74±0.67	1.26±0.67	–	98.00	94.32	
B219	$BC_2 S_{10}$	13.20±0.29	0.80±0.29	–	98.15	97.92	
B220	$BC_2 S_{10}$	12.92±0.15	1.08±0.15	–	96.85	98.94	
B221	$BC_2 S_{10}$	13.76±0.11	0.24±0.11	–	96.06	95.05	
B224	$BC_2 S_{10}$	13.43±0.30	0.57±0.30	–	90.75	97.94	
B225	$BC_2 S_{10}$	12.80±0.20	0.90±0.18	0.60±0.31	89.72	97.03	
B226	$BC_2 S_{10}$	13.64±0.20	0.36±0.20	–	92.70	94.28	
B227	$BC_2 S_{10}$	13.50±0.19	0.50±0.19	–	95.73	98.28	
B229	$BC_2 S_{10}$	13.22±0.21	0.67±0.16	0.22±0.15	92.90	97.61	
B230	$BC_2 S_{10}$	13.25±0.25	0.75±0.25	–	89.85	96.59	
B231	$BC_2 S_{10}$	13.33±0.21	0.67±0.21	–	94.48	95.41	
B232	$BC_2 S_{10}$	12.50±0.45	1.20±0.42	0.60±0.31	94.01	95.93	
B237	$BC_3 S_9$	12.86±0.34	1.14±0.34	–	88.98	95.85	
B240	$BC_3 S_9$	13.29±0.18	0.71±0.18	–	91.60	97.11	
B459	$BC_2 S_5$	13.29±0.18	0.71±0.18	–	95.94	95.24	
B469	$BC_2 S_5$	13.57±0.20	0.43±0.20	–	96.35	85.20	
B474	$BC_2 S_5$	13.00±0.38	1.00±0.38	–	94.57	96.10	
B495	$BC_2 S_5$	13.09±0.21	0.91±0.21	–	94.12	95.70	segregating
B516	$BC_2 S_5$	12.82±0.35	1.18±0.35	–	90.42	94.19	
B518	$BC_2 S_5$	12.82±0.30	1.18±0.30	–	96.56	98.75	segregating
B557	$BC_2 S_5$	13.20±0.29	0.80±0.29	–	92.30	94.55	highly sterile
B711	$BC_2 S_{10}$	12.90±0.18	1.10±0.18	–	96.14	97.17	
B764	$BC_2 S_{10}$	13.45±0.16	0.55±0.16	–	93.92	98.83	
B766	$BC_2 S_{10}$	13.64±0.21	0.36±0.21	–	94.26	96.23	
B1337	$BC_2 S_5$	13.46±0.18	0.54±0.18	–	96.43	97.79	
B1553	$BC_2 S_5$	12.88±0.25	1.06±0.24	0.11±0.11	94.19	94.32	
CD (P=0.05)					1.43	1.08	

BC_n = No. of back crosses

S_n = No. of selfed generation

showing meiotic regularity, irregular meiosis in few derivatives should not be considered as a negative point against interspecific hybridization. Such irregularities may arise sometimes in well established varieties, derived through intervarietal (intraspecific) crosses, like 'Kalyansona' (Singh and Joshi, 1974) which is cytologically unstable due to the presence of translocations leading to multivalent formation. 'Kalyansona' has been the most popular bread wheat variety and played a leading role in revolutionizing wheat production in India.

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VARIABILITY FOR CERTAIN PANICLE AND PHYSIOLOGICAL TRAITS AND THEIR RELATIONSHIPS IN RAINFED RICE

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ABSTRACT

Fifty-four exotic and indigenous rice accessions suitable for rainfed agro-ecology were evaluated for panicle traits, flag leaf area at anthesis and chlorophyll content (SPAD value) at anthesis, 10, 15 and 22 days after anthesis to know extent of variation and interrelationships. The maximum variability was observed for high-density grain index (CV 81.5%) followed by secondary branches/panicle (CV 33.3%). Panicle weight, spikelets/panicle and grain weight also varied appreciably. Flag leaf area at anthesis had considerable variation. The SPAD values showed wide variability that increased with the progressive grain growth period. Chlorophyll content measured as SPAD values, decreased by 28.3% from anthesis to 22 days after anthesis. Jhilidhan, Samanto and Nardha had the minimum reduction (about 11%), thereby suggesting slow leaf senescence. Panicle length, weight, primary, secondary branches and spikelets were positively and significantly interreleted. SPAD values at 10, 15 and 22 days after anthesis showed positive and significant associations with grain weight. The promising accessions for various panicle traits and slow reduction in chlorophyll content were identified which could be used in the cultivar development programme.

Key words : Chlorophyll content, flag leaf area, panicle traits, Oryza sativa L., rice, SPAD values

Grain yield in rice is the culmination of additive and multiplicative interactive effects of various physiological processes reflected in yield components. Panicle traits such as spikelets/panicle, primary branches, secondary branches/panicle, length and weight have the direct bearing on the grain yield in rice. In the rainfed environment, especially upland heavy panicles is the desirable trait, whereas, in low lands it is panicle number which is the main yielding contributing character. It is therefore, partinent to evaluate rainfed germplasm for panicle characters for choosing appropriate donors for utilization in the hybridization programme. Variability in panicle traits has also been studied earlier (Chauhan *et al.* 1989, Borbora and Hazarika, 1998, Sharma and Dubey. 1997). Nutrients like nitrogen plays a key role in harnessing the yield potential of a genotype. The high-yielding rice plants have high N concentration through out its growth. High leaf nitrogen is essential for high tillering. The optimum N concentration in leaf blade should be around 2.3 - 4% at early panicle formation stage and 2.2 - 3.3% at heading stage for high yield (Murayama 1979). Floret number/panicle was significantly correlated with N concentration of leaves at heading whereas; 100-kernel weight and yield/plant were correlated with N concentratiojn of upper 2nd and 3rd leaf sheath at 19 days after heading (Zhao, *et al.*, 1999).

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The chlorophyll meter readings measured at SPAD values have been reported to very well correlated with nitrogen content on dry weight basis of rice leaves, chlorophyll content and photosynthetic rate in rice (Turner and Jund, 1991; Jiang and Vergara, 1986; Sarkar *et al.*, 1998). The present investigation is an attempt to study the extent of variety for SPAD values at different developmental stages after anthesis and their interrelationships with panicle traits. This investigation would also help to assess the possibility of selecting plants with high nitrogen use efficiency and delayed leaf senescence in early segregating generations.

MATERIALS AND METHODS

Fifty four rice accessions of diverse origin (exotic and indigenous) and for diverse agro ecologies (rainfed upland, medium and low land) constituted materials for the present investigation. Twenty three-day-old seedlings were transplanted @ one seedling/hill in 2- row plots during the 1995-96 wet season. The rows were 3.2 meter long and distances were 15×15 cm between rows and between plants within-a-row. The fertilizers (N:P:K) @20, 17 and 17 kg/ha were applied one day before transplanting. Forty kg nitrogen/ha was top dressed in two equal splits of 20 kg each at 20 and 30 days after transplanting. The crop was raised as transplanted rainfed. At anthesis flag leaf from main tillers of 10 plants were sampled for leaf area recording using automatic leaf area meter (LICOR 3100). The chlorophyll content as SPAD values was measured on randomly taken 10 plants. Two uppermost flag leaves were used to measure SPAD values using Minolata chlorophyll meter (SPAD 502), two measurements were made on each flag leaf at anthesis, 10, 15 and 22 days after anthesis. Observations on panicle lengh (cm), panicle weight (g), primary and secondary branches/panicle, spikelets/panicle, filled spikelets (%) and 200-grain weight (g) were recorded. A random sample of 200-grains was used to separate high density grains and high-density grain index was computed as described earlier (Chauhan, 1997).

Range, mean and coefficients of variability were computed for each trait to assess variation. Simple correlation coefficients were worked out between different traits following standard statistical methods.

RESULTS AND DISCUSSION

Variability for physiological traits

Flag leaf area at anthesis varied from 17.6 to 33.3 cm^2 with an overall mean of 24.9 ± 0.7 cm^2. This trait had moderate variation (CV 17.4%). Rangi and Mughadi showed the lowest and the highest leaf area, respectively. The chlorophyll content (SPAD values) varied considerably among the genotypes and the variability increased with the progressive stages of grain growth period. The CV increased from 6.3% at anthesis to 15% at 22 days after anthesis indicating genotypic variation for this trait. The differences among the genotypes for chlorophyll content increased. However, the mean chlorophyll content was reduced by 28.3% at 22 days after anthesis as compared to that of anthesis. Accession Bhangani showed the lowest chlorophyll content which reduced from 25.7 at anthesis to 13.2 at 22 days after anthesis (44% reduction). The chlorophyll content ranged from 25.7 (Bhangani) to 34.1 (Thupisall) at anthesis, 21.9 (Bhagani) to 32.1 (Barahsal) at 10 days after anthesis, 17.2 (Bhangani) to 28.9 (Barahsal) at 15 days after anthesis and 14.2 (Bhangani) to 27.3 (Jhillidhan) at 22 days after anthesis. The decrease in content of chlorophyll was minimum in Jhillidhan (HRC 703) and Samanto (HRC 1104), which was about 10.5% from anthesis to 22 days after anthesis. The chlorophyll content reduced considerably during the corresponding period in the accessions Chapasair (HRC 732, 40.3%), Asumarto (HRC 740, 45.4%), Bismania (HRC 1127, 37.3%), Bhangami (NIC 105463, 44.7%), Jhingasall (NIC 105757, 38.7%), Jhingasar (NIC 105810, 44.7%), Badadhan (NIC 105667, 37.9%), Bhojanabhari (NIC 105697, 40.3%), Ajondholi (NIC 105703, 39.7%), Barahsal 1 (HRC 1132, 47.4%) and Panidhan (HRC 1134, 42.3%). The study revealed wide variation in chlorophyll content at all the stages investigated as well as the pattern of decrease was also variable. Nevertheless, all the accessions exhibited reduced chlorophyll content with the progressive grain growth period that could be due to leaf senescence.

Panicle traits

Among all the panicle traits studied in the present investigation, high-density grain index varied the most and filled spikelets the least as evidenced by coefficients of variability (Table 1). Panicle length ranged from 15.8 to 25.1 cm. Panicle weight, an important trait, especially for rainfed cultivars, showed moderate variation. Exotic accessions IRAT 212 and A012-309 had the lowest and the highest number of primary branches/panicle. Secondary branches/panicle revealed appreciable variation (CV 33.3%) with mean 15.6 ± 0.7. Considerable variability was recorded for spikelets/panicle and a low land accession, JBT 4/186 A had the maximum number of spikelets/panicle. A range of 65.6 – 97.7% was observed for filled spikelets. Maximum (6.4 g) and minimum (3.1 g) 200-grain weight was observed, respectively in IRAT 147 and Nagpur 22; exotic and indigenous rainfed upland accessions (Table 1). High-density grain index signifies the extent of grain filling by the accumulated carbohydrates in the interspaces between kernel-and-hullcavity. The genotypes had large variation for high-density grain index and the it ranged from 0 to 96%. The accessions having desirable panicle trait(s) and SPAD value have been listed in Table 2.

Correlations

Since panicle structure, viz., length, primary, secondary branches and number of spikelets have been decided at the panicle initiation stage, the characters in the present study were recorded at the time of anthesis and thereafter, only influenced grain growth. Hence correlations of flag leaf area and chlorophyll content were studied only with filled spikelets, 200-grain weight and high-density grain index. Large leaf area at anthesis seemed to reduce grain filling. The chlorophyll content did not affect grain

Table 1. Range, mean and coefficients of variability (CV) for panicle traits in rainfed rice

Characters	Range	Mean ± SEm	CV(%)
Panicle length (cm)	15.8-25.1 (Kalakeri) (Dhusri)	21.4 ± 0.3	9.5
Panicle weight (g)	2.0-4.5 (Nagpur 22) (A 12 - 309)	2.9 ± 0.1	17.5
Primary branches/panicle	6.3-11.9 (IRAT 212) (A 12 - 309)	9.1 ± 0.2	14.4
Secondary branches/panicle	3.0-25.0 (Silhati) (IRAT 237)	15.6 ± 0.7	33.3
Spikelets/panicle	57.7-159.5 (A 08 - 394) (JBT 4/186A)	102.5 ± 2.8	20.1
Filled spikelets (%)	65.6-97.7 (IRAT 208) (A 12 - 309)	85.3 ± 0.9	7.8
200 - grain weight (g)	3.1-6.4 (Nagpur 22) (IRAT 147)	4.9 ± 0.1	15.2
High-density grain index (%)	0-90.0 (IRAT 146) (Shermar)	32.4 ± 3.6	81.5
Flag leaf area (cm^2)	17.6-33.3 (Rangi) (Mughadi)	24.9 ± 0.7	17.4

growth until 10 days of anthesis. However, 200-grain weight and chlorophyll content were positively and significantly interrelated with each other (Table 3). The grain filling also appeared to be independent of chlorophyll content, however, degree of grain filling was negatively and significantly correlated with it at 10, 15 and 22 days after anthesis (Table 3). Because SPAD values were also indicative of N concentration of leaves and leaf N concentration of 2nd and 3rd uppermost leaf sheath at 19 days after heading, has been reported to influence 1000-kernal weight, therefore, the findings of the present investigation corroborated the earlier reports of Zhao *et al.* (1999). The present study revealed that chlorophyll content at anthesis and thereafter, related more to the translocation of dry matter to grains rather than photosynthesis as number of filled spikelets/panicle remained unaffected by the changes in SPAD values. Flag leaf area at anthesis did not show any relationship with SPAD values, but negatively associated with number of filled spikiest/panicle (Table 3). The findings of the present investigation were in agreement to those of Murayama (1979) who suggested high leaf nitrogen concentration during ripening is essential for dry matter acumulation in grain, consequently, a positive relationship between 200-grain weight and SPAD values.

Panicle length, panicle weight, secondary, primary branches/panicle and

Table 2. List of promising accessions identified

Character	Accessions
Long panicle (> 24 cm)	Dhusri (HRC 1125), Dahia (HRC 741 A), JBT 4/186 A (NIC 105639)
Heavy panicle (>4.0 g)	A 12-309 (HRC 1005), JBT4/186 A (NIC 105639), IRAT 237 (HRC 1073)
More primary branches (>11.0)	JBT 4/186 A (NIC 105639), Nardhi (NIC 105807), Jhingasall (NIC 105757)
Moderate secondary branches (15-17)	Panidubki (HRC 738) Kadamkandhi (NIC 105791), Jhingasar (NIC 105810)
High spikelets (>120)	JBT 4/186 A (NIC 105639), IRAT 237 (HRC 1073), Thupisall (HRC 1138)
High filled spikelets (>92%)	Hirankajli (HRC 1042), Shermar (HRC 1135), GS 529 (HRC 1040)
Heavy grains (> 6g)	IRAT 147 (HRC 1064), Harimondir (HRC 1041) L081-40-CNA45366 (HRC 1085)
High-density grain index (>75%)	Shermar (HRC 1135), Arroz-De-Ai (HRC 1009), Khirasar (HRC 1124)
Large flag leaf area (>30 cm^2)	Mughadi (HRC 1128), Chapasair (HRC 712), Jhingasall (NIC 105757)
Low reduction in SPAD values ($\leq$11%)	Jhillidhan (HRC 703), Samanto (HRC 1104), Nardha (NIC 105808)

Table 3. Correlation between physiological and panicle traits in rainfed rice

Character	Panicle weight	Primary branches	Secondary branches	Spikelets/ panicle	Filled spikelets	200-grain weight	HDI@	Flag leaf area
Panicle length	0.572**	0.490**	0.566**	0.638**	-0.004	-0.231	0.276*	
Panicle weight		0.596**	0.612**	0.733**	0.219	0.135	-0.127	
Primary branches/panicle			0.359**	0.677**	-0.006	0.005	-0.95	
Secondary branches/panicle				0.653**	-0.200	-0.340*	-0.111	
Spikelets/panicle					-0.050	-0.310*	0.023	
Filled spikelets						-0.123	0.240	
200-grain weight							-0.417**	
Flag leaf area					-0.416*	0.042	-0.171	
SPAD values at anthesis					0.032	0.103	-0.215	0.117
10 days after anthesis					0.144	0.630**	-0.340*	-0.228
15 days after anthesis					0.064	0.561**	-0.398**	-0.308
22 days after anthesis					0.077	0.499**	-0.266*	-0.049

@ High-density grain index.
*, **, Significant at 5 and 1% probability level, respectively.

spikelets/panicle were significantly and positively correlated with each other (Table 3). Hence selection of long panicles alone would bring fourth the correlated response in other traits. Nevertheless, it is desirable to recombine long panicles with more primary branches than secondary branches to have high number of spikelets, because spikelets borne on primary branches have been reported to possess heavier grains than those of secondary branches. Number of secondary branches/panicle (r = 0.340*) and spikelets/panicle (r = –0.318*) were significantly and negatively related to 200-grain weight. The relationship between 200-grain weight and high-density grain index was negative and significant (r=-0.417**). Similar relationship has been observed earlier also (Chauhan, 1997) whereas, Sharma and Dubey (1997) did not observe any association between these two traits.

The present study revealed that SPAD values affected grain weight only and neither degree of filling nor number of filled spikelets. Further studies are, therefore, warranted to establish this relationship in nitrogen sufficient and deficient plants to select for high nitrogen use efficient plants based on SPAD values. The genotypes with relatively little variation in SPAD values which could be due to delayed leaf senescence during grain growth period should be utilized in breeding programme to enhance accumulation of dry matter in grains and hence high yield.

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INFLUENCE OF SOIL MOISTURE REGIMES ON PLANT WATER RELATIONSHIPS, GROWTH AND PRODUCTIVITY OF WHEAT (*TRITICUM AESTIVUM* L.) CULTIVARS UNDER SHALLOW WATER TABLE CONDITIONS IN *TARAI* REGIONS OF UTTRANCHAL

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Abstract

Field experiments were conducted at G.B.P.U.A&T, Pantnagar in silty clay loam (*Typic Hapludoll*) for finding out the suitability of wheat cultivars by characterizing their plant water relationships, growth and productivity under shallow water table conditions in Tarai regions of Uttranchal. Treatments consisted of soil moisture regimes (five) in main plot and wheat cultivars (eight) in sub plot. Results showed that under rain fed condition, highest leaf area index (LAI) was found in C 306 and the lowest in UP 368, while under well watered condition, the trend was reversed. Maximum percent reduction in LAI was observed in UP 368 and minimum in C 306. Under rain fed condition, highest dry matter accumulation was found in C 306 and the minimum in UP 368. On the other hand, under well watered condition, it was maximum in HD 2285 and minimum in WL 410. Highest percent reduction in dry matter was recorded in HD 2285 and the minimum in C 306. Under rain fed condition, highest xylem water potential (XWP) was obtained in HD 2281 but under well watered condition, it was observed in HD 2285. Cultivar C 306 maintained lowest XWP under both the conditions. Highest difference in XWP between stressed and well watered condition (XWPsmw) was found in HD 2285 and the lowest in C 306. Transpiration rate (TR) of cultivar HD 2281 was higher under rain fed condition but under well watered condition, it was higher in UP 368. Cultivar C 306 maintained lowest TR under both the conditions. At all the crop stages, highest differences in transpiration rate between well watered and stressed plots (TRwms) was found in UP 368 and lowest in C 306. Cultivar C 306 have shown highest leaf diffusive resistance (LDR) under rain fed as well as well watered conditions. Grain yield of the cultivars was significantly affected by soil moisture regimes and the interactions were significant. Under rain fed condition, highest grain yield was recorded in C 306 which was at par with UP 2113 and WL 410 while under well watered condition, it was highest in RR 21 which was at par with UP 368, HD 2285 and HD 2281. Under rain fed condition, maximum reduction in grain yield was recorded in UP 368 and the minimum in C 306 compared to well watered condition. A significant and positive correlation coefficient between TR and XWP was found (r=0.726) while a significant and inverse relation was found between TR and LDR (=-0.780) and XWP and LDR (=-0.577). A linear, positive and significant relationship was found between relative grain yield and LAI (r=0.893). Based on these parameters, it was found that the cultivars C 306, WL 410 and UP 2113 were most suitable for rain fed and UP 368, HD 2285 and HD 2281 for well watered conditions in shallow water table conditions in *Tarai* regions of Uttranchal.

Key words : Soil moisture regimes, wheat cultivars, plant water relationships, growth, productivity.

Wheat is one of the most important cereal crop, grown in very diverse ecosystem i.e., irrigated and rain fed and there is wide gap between yields of wheat under rain fed and irrigated conditions. The current water use efficiency of wheat is quite low under both the ecosystem. There is immense scope for its improvement by reducing the number and quantity of irrigation water by making best use of rain and underground water. This necessitates an understanding of plant water relationship in wheat for planning irrigations to optimize the use of available water supply. There are only two strategies available for dealing with drought situation in rain fed wheat production, one is to develop necessary water resources for providing supplemental irrigations, which is very costly and input intensive. Another option is to develop wheat genotypes, which are tolerant to moisture stress. Wheat cultivars may vary in their water requirements depending upon the type of leaves and root system for achieving the optimum production. The choice of the suitable cultivar for the conditions of water stress or adequate moisture supply is very important. In certain situations, cultivars are inefficient to utilize the available water to the utmost level to convert in into economic products. Wheat cultivars vary greatly in their sensitivity to water stress. So, it is essential to screen these cultivars for their suitability under rain fed and irrigated conditions based on their plant water relations viz., xylem water potential, transpiration rate ,leaf diffusive resistance etc. In view of the above, field experiments were conducted to find out the suitability of wheat cultivars based on their plant water relationships, growth parameters and productivity under varying soil moisture regimes in shallow water table conditions in *Tarai* region of Uttaranchal.

MATERIALS AND METHODS

Study was conducted at Crop Research Center, G.B. Pant University of Agriculture & Technology, Pantnagar (29^o N latitude, 79^o 30' E longitude and 243.83 m MSL), Udham Singh Nagar, Uttranchal, in silty clay loam (*Typic Hapludoll*) having the characteristics (0-15 cm) - sand 8.8%, silt 61.4%, clay 29.7%, pH 6.3, organic matter 3.4%, EC 0.36 mmhos cm^{-1}, CEC 20 meq/100g, bulk density 1.33 Mg m^{-3} and 34.6 and 11% moisture content at 0.33 and 1.5 MPa, respectively. Experiments were conducted in split-plot design with soil moisture regimes (five) in main-plot [viz., T_1 - rain fed (control), T_2 - irrigation at crown root initiation (CRI), T_3 - irrigations at CRI and flowering (F) stages (well watered), T_4 - irrigations when canopy temperature variability (CTV) $\geq 0.7\ 0$ C and T_5 - irrigations at pre-dawn xylem water potential of - 0.35, -0.65, -0.65, -0.65 and -1.45 MPa at CRI, late tillering (LT), late jointing (LJ), flowering (F) and milk (M) stages, respectively based on the stress day index (SDI) concept (Hiler and Clark, 1971)] and wheat cultivars (eight) in sub-plot viz., UP 115, UP 368, UP 2113, HD 2281, HD 2285, C 306, WL 410 and RR 21] replicated thrice. Measured quantity of water (6.0 cm) was applied in each irrigation by installing 7.5 cm width throat parshall flume in the irrigation channel. Crop also received 39.2 mm of rainfall near CRI stage. In T_4 and T_5 treatments, only one irrigation at flowering stage was applied. Water table depths were monitored with the help of battery-operated cable at weekly interval by installing three piezometers, which fluctuated between 82.0 to 120.0 cm during the growing season of the crop.

Plant water relation parameters viz., xylem water potential (XWP) by portable pressure chamber apparatus (PMS-610) (Scholander *et al.* 1965) and transpiration rate (TR) and leaf diffusive resistance (LDR) were measured by portable steady state porometer (LICOR-LI-1600) at all critical physiological growth stages at alternate days in the post-noon (1330-1400 hrs) during the crop growing seasons. All the observations were made on clear and rainless day. The differences between stressed and well watered conditions for xylem water potential (XWPsmw), and transpiration rate (TRwms) were computed. Plants from 20 cm running row length were harvested and the leaf area was measured at various growth stages with the help of portable leaf area meter (LICOR Model- LI-3000) and the total dry matter of the samples was recorded after its oven drying. Grain yield was recorded and analyzed statistically.

RESULTS AND DISCUSSION

Seasonal Variations in Plant Water Relations

Xylem water potential

In general, XWP decreased with crop age under both the soil moisture regimes (Table 1). The differences in XWP between rain fed and well watered condition begin to increase after 84 DAS and reached maximum after the milk stage (120 DAS). As the days become more bright and warm after the flowering stage (84 DAS), XWP reduced sharply in rain fed and well watered conditions. Blum (1974) and Painuli (1977) also reported that XWP values decreased with age of the plant. The reduction in XWP with crop age may be due to leaf area expansion and an increase in internal plant resistance to water flow during the plant development (Ackerson *et al.* 1977). It was maximum in well watered

Table 1. Effect of soil moisture regimes on seasonal post- noon (1330-1400 hrs) xylem water potential (XWP) (MPa) of wheat cultivars

Cultivars	22 DAS		44 DAS		64 DAS		84 DAS		104 DAS		120 DAS	
	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered
UP 115	-1.00	-0.85	-1.45	-1.35	-1.85	-1.65	-1.85	-1.55	-2.10	-1.85	-2.50	-2.10
UP 368	-0.95	-0.80	-1.40	-1.20	-1.65	-1.50	-1.75	-1.45	-2.00	-1.75	-2.35	-1.95
UP 2113	-1.05	-0.95	-1.50	-1.45	-1.90	-1.70	-2.05	-1.75	-2.30	-2.05	-2.65	-2.30
HD 2281	-0.95	-0.80	-1.30	-1.15	-1.55	-1.50	-1.80	-1.45	-2.00	-1.70	-2.30	-1.95
HD 2285	-0.95	-0.75	-1.35	-1.15	-1.65	-1.50	-1.80	-1.40	-2.05	-1.70	-2.30	-1.90
C 306	-1.05	-0.95	-1.60	-1.45	-1.90	-1.75	-2.00	-1.75	-2.35	-2.10	-2.70	-2.35
WL 410	-1.05	-0.90	-1.35	-1.40	-1.85	-1.70	-2.05	-1.80	-2.25	-2.00	-2.65	-2.30
RR 21	-1.00	-0.80	-1.40	-1.30	-1.80	-1.65	-1.90	-1.55	-2.10	-1.80	-2.55	-2.10

and minimum in rain fed condition. There was a continuous decrease in XWP except an increase on 84 DAS after second irrigation in all the cultivars except UP 2113, WL 410 and C 306. As drought prolonged, differences among the treatments became large. Shimshi *et al.* (1982) also observed a rapid decrease in XWP with increasing water stress in wheat. In rain fed condition, highest XWP was observed in HD 2281, which was close to HD 2285 and UP 368 but under well watered condition, highest XWP was observed in HD 2285. Cultivar C 306 maintained the lowest XWP both in rain fed and well watered conditions, which was close to UP 2113 and WL 410. Cultivars UP 115 and RR 21 maintained intermediate values of XWP both in rain fed and well watered conditions.

Under rain fed condition, XWP of HD 2281, HD 2285 and UP 368 ranged from -0.95 to -1.55, -0.95 to -1.65, and -0.95 to -1.65 and from -1.80 to -2.30, -1.80 to -2.30 and -1.75 to -2.35 MPa during 22 to 64 and 84 to 120 DAS, respectively. XWP of RR 21 and UP 115 was 1.05 to 1.11 times and XWP of WL 410, UP 2113 and C 306 was 1.10 to 1.17 times lower than that of HD 2281 indicating the preference of these cultivars for maintaining lower XWP under rain fed condition. Different cultivars may exhibit different XWP's under similar soil and atmospheric conditions (Sivakumar and Virmani, 1979). XWP of HD 2285, HD 2281, and UP 368, in well watered condition, ranged from -0.75 to -1.50, - 0.80 to -1.50 and -0.80 to -1.50 and from -1.40

to -1.90, -1.45 to -1.95 and -1.45 to -1.95 MPa during 22 to 64 and 84 to 120 DAS, respectively. XWP of RR 21 and UP 115 was 1.11 to 1.13 times and XWP of WL 410, UP 2113 and C 306 was 1.24 to 1.27 times lower than that of HD 2285. Jones (1977) also found genotypic variations in XWP among cultivars of wheat.

XWPsmw

Differences in xylem water potential between stressed and well watered conditions increases with crop age (Table 2). More prominent differences were recorded on 84 DAS, which might be due to higher transpiration rates resulting in lowering of XWP due to reduced availability of soil water on account of higher water extraction by roots to meet the transpiration requirement of the cultivars. Maximum differences in XWP were recorded on 120 DAS when crop was near maturity. On 84 DAS, highest XWPsmw was recorded in HD 2285 (-0.40 MPa), which was close to UP 368, HD 2281 and RR 21. On the other hand, lowest XWPsmw was recorded in C 306 (-0.25 MPa). However, on 120 DAS, highest XWPsmw was recorded in RR 21 (-0.45 MPa) and the lowest in C 306 (-0.35 MPa). This shows that at any time during the growing season, in general, cultivars UP 368, HD 2285 and HD 2281 were more sensitive to water stress due to higher values of XWPsmw and the cultivars C 306, WL 410 and UP 2113 were resistant to water stress due to lower values of XWPsmw. This might be used as one of the indicators

Table 2. Effect of soil moisture regimes on seasonal post- noon (1330-1400 hrs) xylem water potential of stressed minus well watered XWPsmw (MPa) of wheat cultivars

Cultivars	22 DAS	44 DAS	64 DAS	84 DAS	104 DAS	120 DAS
UP 115	-0.15	-0.10	-0.20	-0.30	-0.25	-0.40
UP 368	-0.20	-0.20	-0.15	-0.35	-0.25	-0.40
UP 2113	-0.10	-0.10	-0.20	-0.30	-0.25	-0.35
HD 2281	-0.15	-0.15	-0.05	-0.35	-0.30	-0.35
HD 2285	-0.20	-0.20	-0.20	-0.40	-0.35	-0.40
C 306	-0.10	-0.15	-0.15	-0.25	-0.25	-0.35
WL 410	-0.15	-0.15	-0.15	-0.25	-0.25	-0.35
RR 21	-0.20	-0.15	-0.15	-0.35	-0.30	-0.45

Table 3. Effect of soil moisture regimes on seasonal post-noon (1330-1400 hrs) transpiration rate (µg cm^{-2} sec^{-1}) of wheat cultivars

Cultivars	44 DAS		64 DAS		84 DAS		104 DAS		117 DAS	
	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered
UP 115	6.14	7.81	8.39	10.42	9.16	12.83	9.81	18.84	4.42	11.12
UP 368	6.53	8.26	8.62	10.81	9.73	15.34	10.63	20.85	5.43	14.53
UP 2113	5.14	6.75	7.39	8.89	7.66	10.95	8.42	12.73	3.53	7.42
HD 2281	6.70	8.11	8.83	10.69	9.81	13.16	10.74	20.03	5.53	14.26
HD 2285	6.61	8.17	8.70	10.80	9.77	14.18	10.68	20.46	5.48	14.41
C 306	4.96	6.68	7.26	8.64	7.35	10.25	8.13	12.46	3.40	7.24
WL 410	5.01	6.75	7.32	8.73	7.55	10.41	8.26	12.58	3.42	7.38
RR 21	6.19	7.91	8.49	10.58	9.30	13.01	10.16	18.90	4.51	11.46

Table 4. Effect of soil moisture regimes on seasonal post-noon (1330-1400 hrs) transpiration rate (µg cm^{-2} sec^{-1}) of well watered minus stressed TRwms of wheat cultivars

Cultivars	44 DAS	64 DAS	84 DAS	104 DAS	117 DAS
UP 115	1.67	2.03	3.67	9.03	6.70
UP 368	1.73	2.19	5.61	10.22	9.10
UP 2113	1.61	1.50	3.29	4.31	3.89
HD 2281	1.41	1.86	3.35	9.29	8.73
HD 2285	1.56	2.10	4.41	9.78	8.93
C 306	1.72	1.38	2.90	4.33	3.84
WL 410	1.74	1.41	2.86	4.32	3.96
RR 21	1.72	2.09	3.71	8.74	6.95

for screening of cultivars for its suitability to varying water situations.

Transpiration rate

Seasonal post-noon (1330-1400 hrs), transpiration rate (TR) from 44 to117 DAS was measured (Table 3). In all the cultivars, TR increased with crop age up to 104 days stage but the rate of increase was higher under well watered compared to rain fed condition and reduced sharply thereafter because of senescence. A steep rise in TR was observed between 44 to 64 DAS. It was highest in HD 2281 under rain fed condition and in UP 368 under well watered condition. TR of HD 2281, HD 2285 and UP 368 was at par with each other both in rain fed and well watered conditions. Cultivar C 306 maintained lowest TR under both the conditions and was similar to the TR of WL 410 and UP 2113. The higher TR in HD 2281, HD 2285 and UP 368 might be due to relatively higher LAI and better root growth as compared to other cultivars. Kirkham *et al.* (1980) also reported that leaf area was directly related to water loss in wheat. Highest TR under rain fed as well as well watered condition was recorded on 104 DAS. Under rain fed condition, maximum TR was found in HD 2281 (10.74 $\mu g\ cm^{-2}\ sec^{-1}$) and the minimum in C 306 (8.13 $\mu g\ cm^{-2}\ sec^{-1}$) but under well watered condition, maximum TR was recorded in UP 368 (20.85 $\mu g\ cm^{-2}\ sec^{-1}$) and the minimum in C 306 (12.46 $\mu g\ cm^{-2}\ sec^{-1}$).

TR of HD 2281, HD 2285 and UP 368, in rain fed condition, ranged from 6.70 to 8.83, 6.61 to 8.70 and 6.53 to 8.62 and from 9.81 to 10.74, 9.77 to 10.68, 9.73 to 10.63, $\mu g\ cm^{-2}\ sec^{-1}$ during 44 to 64 and 84 to 104 DAS, respectively. TR of RR 21 and UP 115 was 1.06 to 1.17 times and TR of C 306, WL 410 and UP 2113 was 1.32 to 1.45 times lower than that of HD 2281. On the otherhand, under well watered condition, TR in UP 368, HD 2285 and HD 2281 ranged from 8.26 to 10.81, 8.17 to 10.80, and 8.11 to 10.69 and from 15.34 to 20.85, 14.18 to 20.46 and 13.16 to 20.03 $\mu g\ cm^{-2}\ sec^{-1}$ during 44 to 64 and 84 to 104 DAS, respectively. TR of RR 21 and UP 115 was 1.06 to 1.19 times and TR of UP 2113, WL 410 and C 306 was 1.24 to 1.50 times lower than that of UP 368.

TRwms

Differences in transpiration rate between well watered and stressed condition (TRwms) increased continuously with crop age from 44 to 104 DAS (Table 4). The values almost doubled on 104 DAS compared to 84 DAS. At all crop growth stages, highest TRwms was recorded in UP 368, which was close to HD 2285 and HD 2281 and the lowest in C 306 which was close to WL 410 and UP 2113. The values for other cultivars fall in between. On 104 DAS, highest TRwms was recorded in UP 368 (10.22 $\mu g\ cm^{-2}\ sec^{-1}$), which was close to HD 2285 and HD 2281 and the lowest in UP 2113 (4.31$\mu g\ cm^{-2}\ sec^{-1}$), which was close to WL 410 and C 306. The values for other cultivars fall in between.

Leaf diffusive resistance

LDR measured during 1330-1400 hrs on rainless days from 44 to 117 DAS are presented in Table 5. In general,

Table 5. Effect of soil moisture regimes on leaf diffusion resistance (sec cm^{-1}) of wheat cultivars

Cultivars	44 DAS		64 DAS		84 DAS		104 DAS		117 DAS	
	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered	Rain fed	Well watered
UP 115	1.15	0.79	1.19	0.85	1.36	0.91	1.50	1.18	1.86	1.43
UP 368	1.07	0.69	1.11	0.73	1.24	0.80	1.30	1.04	1.52	1.21
UP 2113	1.19	0.86	1.35	0.98	1.73	1.32	2.32	2.04	3.31	2.43
HD 2281	1.04	0.71	1.08	0.78	1.20	0.87	1.25	1.13	1.46	1.25
HD 2285	1.05	0.70	1.10	0.74	1.22	0.83	1.28	1.07	1.49	1.23
C 306	1.20	0.88	1.49	1.02	1.94	1.50	2.69	2.22	3.42	2.67
WL 410	1.20	0.87	1.41	1.00	1.81	1.43	2.57	2.14	3.37	2.60
RR 21	1.12	0.76	1.17	0.83	1.30	0.90	1.46	1.16	1.83	1.41

LDR increased with crop age in all the cultivars under both the moisture regimes. Highest values of LDR were observed on 117 DAS. It was maximum under rain fed and minimum under well watered conditions. The magnitude of LDR was always maximum under rain fed and minimum under well watered conditions. Under rain fed condition, changes in LDR were smaller during 44 to 64 DAS followed by an increase until 104 DAS. A faster increase in LDR was recorded during 104 and 117 DAS. Henson *et al.* (1982) also reported that water stress decreased the amplitude of mid-day peak stomatal conductance and the time over which conductance was maintained. Almost, a similar pattern with lower magnitude was observed under well watered conditions. Maximum differences between rain fed and well watered were found on 84 DAS. Cultivar C 306 have shown highest LDR under well watered (1.50 sec cm^{-1}) as well as rain fed (1.94 sec cm^{-1}) while the cultivars UP 368 and HD 2281 have shown the minimum 0.80 and 1.20 sec cm^{-1} under well watered and rain fed conditions, respectively. Cultivar HD 2281 maintained lowest LDR under rain fed and UP 368 under well watered conditions. LDR of UP 115 and RR 21 occupied an intermediate position.

Under rain fed condition, LDR of HD 2281, HD 2285 and UP 368 ranged from 1.04 to 1.08, 1.05 to 1.10 and 1.07 to 1.11 and from 1.20 to 1.46, 1.22 to 1.49, 1.24 to 1.52, sec cm^{-1} during 44 to 64 and 84 to 117

Table 6. Effect of soil moisture regimes on leaf area index (LAI) and its percent reduction in wheat cultivars

Cultivars	41 DAS			64 DAS			85 DAS			102 DAS			Overall
	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	percent reduction
UP 115	2.23	2.89	22.8	3.20	4.34	26.3	4.60	7.34	37.3	3.12	4.56	31.6	29.5
UP 368	2.53	3.17	20.2	3.10	5.71	45.7	3.34	9.64	65.3	2.73	5.50	50.4	45.4
UP 2113	2.79	2.97	6.1	3.91	4.96	21.2	5.21	7.52	30.7	3.88	4.92	21.1	19.8
HD 2281	2.74	3.06	10.5	3.19	5.19	38.5	3.72	8.26	55.0	2.89	5.24	44.8	37.2
HD 2285	2.70	3.08	12.3	3.16	5.43	41.8	3.38	8.83	61.7	2.86	5.36	46.6	40.6
C 306	2.81	2.86	1.7	3.85	4.04	4.70	5.80	7.18	19.2	3.96	4.67	15.2	10.2
WL 410	2.74	2.90	2.1	3.83	4.15	7.70	5.05	7.32	31.0	3.77	4.82	21.8	15.7
RR 21	2.15	2.92	26.4	3.17	4.67	32.1	4.09	7.87	48.0	3.02	4.75	36.4	35.7

DAS, respectively. In RR 21 and UP 115, it was 1.11 to 1.13 times and in UP 2113, WL 410 and C 306, it was 1.15 to 1.67 times higher than that of HD 2281. But under well watered condition, LDR of UP 368, HD 2285 and HD 2281 ranged from 0.69 to 0.73, 0.70 to 0.74, and 0.71 to 0.78 and from 0.80 to 1.21, 0.83 to 1.23 and 0.87 to 1.25 sec cm^{-1} during 44 to 64 and 84 to 117 DAS, respectively. In RR 21 and UP 115 it was 1.14 to 1.18 times higher but in UP 2113, WL 410 and C 306, it was 1.28 to 1.88 times higher than that of UP 368.

Growth and Productivity

Leaf area index

It was measured on 41, 64, 85 and 102 DAS (Table 6). LAI of all the cultivars increased continuously from 41 to 85 DAS and decreased thereafter due to senescence. Highest LAI was found near flowering stage (85 DAS). At any stage, higher LAI was recorded under well watered compared to rain fed condition. Almost all the cultivars behaved similarly throughout the growing seasons. Singh *et al.* (1979) also observed the highest LAI in wheat at 80 DAS and the maximum LAI was observed when the crop was irrigated at all the physiological stages. Under rain fed condition, highest LAI was found in C 306 (5.80) which was close to UP 2113 and WL 410 and the lowest in UP 368 (3.34) which was close to HD 2285 and HD 2281. On the other hand, under well watered condition, highest LAI was recorded in UP 368 (9.64) and the lowest in C 306 (7.18).

Percent reduction in LAI was calculated as (1-Ly/Li) x100 where Ly

Table 7. Effect of soil moisture regimes on dry matter production (g) and its percent reduction in wheat cultivars

Cultivars	41 DAS			64 DAS			85 DAS			102 DAS			Overall percent reduction
	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	Rain fed	Well watered	Percent reduction	
UP 115	25.6	37.0	30.8	107.6	160.4	32.9	243.1	346.5	29.8	385.0	655.4	41.3	33.7
UP 368	19.4	37.7	48.5	88.2	162.9	45.8	213.1	377.2	43.5	320.9	715.4	55.1	48.2
UP 2113	28.2	36.9	23.6	126.7	152.0	16.6	276.2	412.9	33.1	478.0	706.3	32.8	26.4
HD 2281	22.7	40.9	44.4	115.5	165.9	30.4	239.0	382.2	37.5	346.1	720.0	51.9	41.1
HD 2285	20.3	43.0	52.8	96.0	172.6	44.4	230.7	416.9	44.7	338.4	767.2	55.9	49.5
C 306	31.3	35.8	12.6	132.5	150.3	11.8	277.5	323.6	14.2	480.5	638.0	24.7	15.8
WL 410	28.0	34.2	18.1	121.0	143.7	15.8	273.9	337.9	18.9	449.9	577.8	22.1	18.7

is the LAI in rain fed and Li is that in well watered condition . It also increases with crop age, which was maximum at 85 DAS but decreased slightly on 102 DAS. Maximum percent reduction was observed in UP 368 (45.4%) followed by HD 2285 (40.6%), HD 2281 (37.2%), RR 21 (35.7%), UP 115 (29.5%), UP 2113 (19.8%), WL 410 (15.7%) and the minimum in C 306 (10.2%). Higher reduction in LAI in UP 368, HD 2285 and HD 2281 indicated more sensitivity of these cultivars to water stress compared to C 306, WL 410 and UP 2113, which were more tolerant to water stress. If we allow ten percent possible variation under field conditions than a LAI reduction interval of 0-10, 10-20 percent, etc. can be conveniently chosen to group the cultivars. Upon doing this, it was observed that none of the cultivar falls in 0-10 percent interval. The cultivars falling in 10-20 percent reduction interval are C 306, WL 410 and UP 2113, in 20-30 percent reduction is UP 115, in 30-40 percent reduction are HD 2281 and RR 21 and in 40-50 reduction are UP 368 and HD 2285.

Dry matter accumulation

Dry matter accumulation was recorded on 41, 64, 85,and 102 DAS (Table 7). In all the cultivars, it increased continuously with crop age from 41 to 102 DAS. At all the stages, it was higher under well watered compared to rain fed condition. Gales *et al.* (1984) also found that drought has restricted the dry matter production of wheat. Water stress at early stages

Table 8. Effect of soil moisture regimes on grain yield and percent yield reduction of wheat cultivars

Cultivars	Grain yield (t ha^{-1})			Percent yield reduction
	Rain fed	Well watered	Mean	
UP 115	3.02	4.83	3.93	37.6
UP 368	2.27	5.21	3.74	56.5
UP 2113	3.15	4.24	3.70	25.7
HD 2281	2.58	4.99	3.79	48.1
HD 2285	2.43	5.15	3.79	52.9
C 306	3.40	4.10	3.75	17.1
WL 410	3.12	4.15	3.64	25.8
RR 21	2.92	5.44	4.18	46.6
Mean	2.86	4.76		
C.D. (0.05)	Soil moisture regimes		0.18	
	Cultivars		0.21	
	Soil moisture regimes x Cultivars		0.45	

(CRI and LT) reduces dry weight of shoots of wheat plant (Gajri and Prihar, 1983). Under rain fed condition, at any stage, highest dry matter production was recorded in C 306, which was close to UP 2113, and WL 410 and the lowest in UP 368, which was close to HD 2285 and HD 2281. However, under well watered condition, it was highest in HD 2285 and lowest in WL 410. This shows that the cultivars HD 2285, UP 368 and HD 2281 were more sensitive to stress compared to cultivars C 306, WL 410 and UP 2113 were least sensitive to stressed condition.

Percent reduction in dry matter, calculated as (1- Dy/Di)x100 where Dy is the maximum dry matter accumulation in rain fed and Di is that in well watered shows that maximum reduction in dry matter was recorded in HD 2285 (49.5%) followed by UP 368 (48.2%), HD 2281 (41.1%), RR21 (37.9%), UP 115 (33.7%), UP 2113 (26.4%), WL 410 (18.7%) and least in C 306 (15.8%). If we allow ten percent possible variation under field conditions, then a dry matter reduction interval of 0-10, 10-20, 20-30, 30-40 and 40-50 percent can be conveniently chosen for grouping the cultivars. It was observed that none of the cultivar fall in 0-10 percent interval. The cultivars falling in 10-20 percent reduction were WL 410 and C 306. UP 2113 falls in 20-30 percent reduction. The cultivars falling in 30-40 percent reduction are RR 21 and UP 115 and in 40-50 percent reduction are HD 2285, UP 368 and HD 2281.

Crop productivity

Grain yield of all the cultivars was significantly influenced by soil moisture regimes and the interactions were significant (Table 8). Significantly higher grain yield was recorded under well watered as compared with rain fed condition. Malik (1978) also observed that effect of irrigation was significant on the grain yield of dwarf as well as tall wheat. Under well watered condition, highest grain yield was recorded in RR 21 (5.44 t ha^{-1}) which was at par with UP 368, HD 2285 and HD 2281 and the minimum in C306 (4.10 t ha^{-1}). On the other hand, under rain fed condition, maximum grain yield was recorded in C 306 (3.40 t ha^{-1}), which was at par with UP 2113, WL 410, UP 115 and RR 21 but significantly higher than the remaining cultivars.

Percent reduction in yield, calculated as (1-Yr/Yi) x100 where Yr is yield under rain fed and Yi is the yield under well watered condition in the range of 0-20, 20-40 percent and so on was minimum in C 306 (17.1%) which can be placed in first category. Similarly, three cultivars (UP 2113, UP 115 and WL 410) falls in second category in which 25.7 to 37.6 percent reduction (20-40 percent) in grain yield was observed and cultivars UP 368, HD 2281, HD 2285 and RR 21 falls in the third category in which 46.6 to 56.5 percent reduction (40-60 percent) in grain yield was recorded. This shows that cultivars UP 368, HD 2281 and HD 2285 were more sensitive to water stress compared to C 306, WL 410, UP 2113 which were found to be tolerant to drought condition. Day and Intalap (1970) also found that stress at jointing stage in wheat yielded about 50% less than when grown under optimum irrigation conditions.

Inter Relationships

In order to generalize the results on plant water parameters, inter relationships among various parameters were worked out. Measurements of XWP, TR and LDR made on eight wheat cultivars during 1330-1400 hrs on rainless days were used to develop relationships among the above mentioned plant water parameters. The correlation coefficient between TR and XWP (Fig. 1) were significant. Stocker and Weatherly (1971) also found a linear relationship between depression of XWP and TR. The correlation coefficient between TR vs LDR was significant (r=0.726). As shown in the Fig. 2a, transpiration rate was inversely related with LDR (r=-0.780). Monteith *et al.* (1965) also reported that transpiration decreased with increase in stomatal diffusion resistance. A linear relationship was observed between XWP and LDR (r=-0.577) (Fig. 2 b). Kateriz

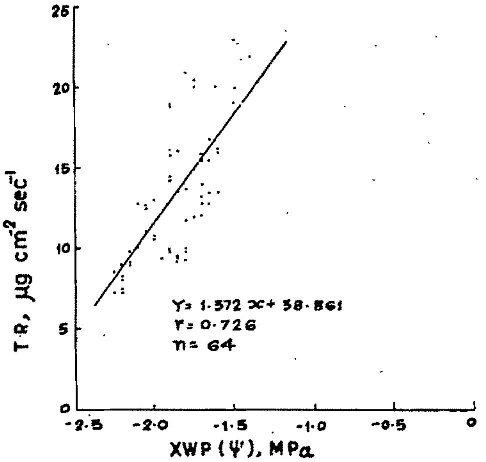

Fig. 1 Regression of TR on XWP (ψ) measured during 1330-1400 h.

(1979) also showed a direct relationship between DR and XWP with increasing water deficit. Results showed that plant water relations were functionally interrelated. They were, in general, affected by soil water and environmental conditions, and plant characteristics.

Production function

These are considered as valuable tools in crop planning and management. LAI was regressed with relative grain yield. A linear relationship with positive slope suggests that relative grain yield was positively related to LAI.

Y= 0.892 (LAI) + 0.231, r=0.893**, n=40, Y= relative grain yield, ** - significant at 5 and 1 percent level of significance.

It can be concluded that the plant water relationships can be used as efficient and effective parameters for finding the suitability of wheat cultivars under varying water situations. Based on XWP, TR, LDR, XWPsmw and TRwms, the cultivars were categorized in three distinct groups. Cultivars of group I (drought avoidant - water spender) (UP 368, HD 2281, and HD 2285) showed the highest XWP, TR, XWPsmw, TRwms and lowest LDR . Cultivars of group II (drought avoidant-water saver) (UP 115 and RR 21) showed intermediate XWP, TR, XWPsmw, TRwms and LDR. On the other hand, the cultivars of group III (drought tolerant) (C 306, UP 2113 and WL 410) showed the lowest XWP, TR, XWPsmw, TRwms and highest LDR. It was found that out of all the cultivars, C 306, WL 410 and UP 2113 were found to be the most suitable under rain fed condition and UP 368, HD 2285 and HD 2281 were most suitable cultivars under well watered condition due to maintenance of favorable plant water relations under shallow water table conditions in *Tarai* regions of Uttranchal.

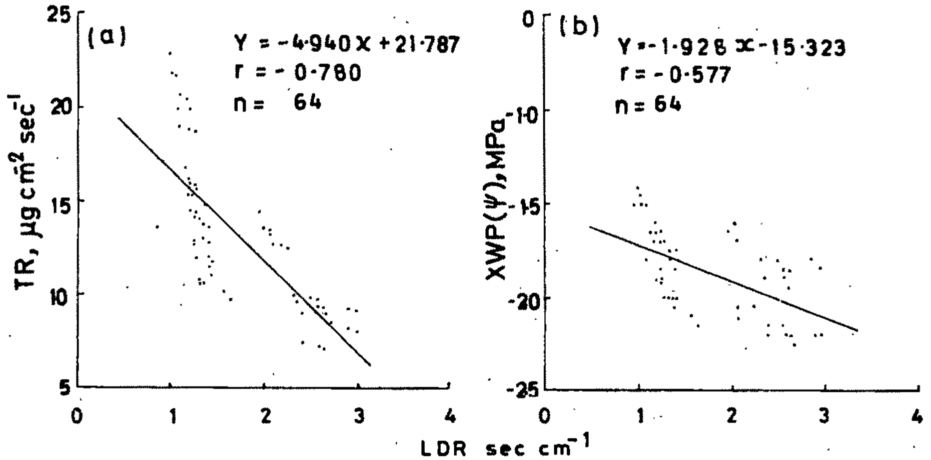

Fig. 2. Regression of (a) TR on LDR, (b) XWP (ψ) on LDR measured during 1330-1400 h.

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EFFECT OF WEED MANAGEMENT PRACTICES IN A RICE-MUSTARD-MUNGBEAN CROPPING SYSTEM ON WEEDS AND YIELD OF CROPS

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ABSTRACT

Results obtained showed that weed competition in rice-mustard-mungbean a three course cropping system lowered the total grain productivity by 32% while the maximum decrease in grain productivity of rice, mustard and mungbean was 35.3%, 19.3% and 45.6%, respectively. The most potent weed species that competed were *Echinochloa colonum* and *E. crasgalli* in rice, *Phalaris minor* in mustard and *Trianthema portulacastrum* in mungbean. The competitive effect of other weed species on grain yield was nominal as their population was sparse. In all the three crops in weed control treatments weed population and weed dry weight were recorded significantly lower. Chemical + cultural, handweeding and chemical treatments resulted in marked decrease in weeds. The former two treatment resulted in higher decrease. Weed control treatments caused significant increase in grain yield of crops in both the years. Chemical + cultural and hand weeding effected higher increase in grain yield of rice while hand weeding and chemical in mustard and mungbean.

Key words : *Oryza sativa, Brassica juncea, Vigna radiata,* anilofos, fluchoralin, pendimethalin.

Rice-wheat a two course cropping system is most populent system in Southeast-Asia and is the backbone of food security in this region. But continuous cropping of these two cereal crops in sequence for more than three and half decades has brought froth the problem of nutrient imbalance in upper soil layer and decline in productivity of this system. Besides there is perceptible change in weed flora. Weed flora has enlarged, uncommon weeds are rampant and common weeds are more virulent. Unbeaten weeds *Echinochloa colonum, E. Crusgalli, Cyperus rotundus* in rice and *Phalaris minor* in wheat have beset the cultivation of these crops. Infestation of weeds on an average, lowers yield of these crops by 30% (Singh, 1975, Pandey *et al.* 1980, Pandey and Singh, 1997). Total failure of crop is not uncommon. To extenuate the weed threat and to avoid nutrient imbalance wheat crop is being substituted by mustard, a deep rooted crop and mungbean is taken as catch crop after it to improve the impoverished soil. In mustard *Phalaris minor* grows widely between widely spaced rows of mustard plants, it is easily distinguished and removed or killed. Mustard does not create the problem of nutrient imbalance in upper soil layer as it mines most of its nutrient from deeper soil layer. Succeeding summer mungbean crop is very vulnerable to weed competition (Pandey 1980, Brar *et al.* 1981).

A most common weed *Trianthema portulacastrum* if not controlled in time completely suppresses the crop. Thus management of weeds in rice-mustard-mungbean a three course cropping system is imperative to maximize yield potential of the system. The present study was undertaken to study the effect of different weed management practices on weeds and yield of crops in the rice-mustard-mungbean a three course cropping system.

MATERIALS AND METHODS

A field experiment was conducted during two crop years (1997-1999) at the Indian Agricultural Research Institute, New Delhi. The soil of experimental plot was sandy clay loam having 52.8% sand, 21.5% silt and 25% clay, pH 8 (1:2.5 soil to water ratio), 275 kg N ha^{-1}, 20.5 kg P ha^{-1} and 180 kg K ha^{-1}, Rice-wheat system had been practiced in the field for last 12 years.

The experiment having five weed control treatments; weedy check, hand weeding, chemical, cultural, and chemical + cultural was conducted in randomized block design with six replications. Herbicides anilofos @ 0.500 kg a.i. ha^{-1}, fluchloralin @ 75 kg a.i. ha^{-1} and pendimethalin @ 1.0 kg a.i. ha^{-1} were applied in rice, mustard and mungbean, respectively.

Twenty five days old seedlings of rice variety Pusa 834 having two to three seedlings per hill were transplanted at a spacing of 15×10 cm on July 10 and harvested on October 15, mustard variety Pusa Bold was sown at spacing of 30×10 cm on Oct. 26 and harvested on March 25, and mungbean variety PS 16 was sown at a row spacing of 25 cm on April 5 and harvested on June 15 each year.

Herbicide anilofos was applied 4 days after transplanting and lfuchloralin and pendimethalin a day after sowing using a volume spray of 600 l ha^{-1}. Handweeding in rice was done 30 days after transplanting while in mustard and mungbean 20 days after sowing. In cultural treatment a hand driven wooden hand plough was run between the line 35 days after sowing.

Rice was given 100 kg N ha^{-1} 15 kg P ha^{-1} and 20 kg K ha^{-1} and mustard 60 kg N ha^{-1} and 120 kg P ha^{-1}. Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muriate of potash respectively. Mungbean was fertilized at the rate of 20 kg N ha^{-1} and 22 kg P ha^{-1} through diammonium phosphate.

Weed data were transformed (x+0.5) before statistical analysis.

RESULTS AND DISCUSSION

Effect of weed control treatments on weeds

Data on weed population and weed dry weight are given in Tables 1 and 2, respectively.

In both the years (1997-98) rice was invaded by *Echinochloa colonum, E. crusgalli, Lepochloa chinensis. Cyperus rotundus* and *Eclipta, alba.* Of the weed species E. colonum was most potent competitor. E. crusgalli competed keenly but

Table 1. Weed population (no. 0.25 m^{-2} 60 DAT/DAS) as affected by weed control treatments in different crops in rice-mustard-mungbean cropping system

Treatments	1997-98			1998-99		
	Rice	Mustard	Mungbean	Rice	Mustard	Mungbean
Weedy check	4.68	12.05	5.63	4.22	11.43	5.83
Handweeding	2.70	2.52	2.13	2.08	3.87	2.58
Chemical	2.82	4.62	2.58	2.61	4.10	2.73
Cultural	3.55	5.23	3.58	3.51	5.08	3.48
Chemical+Cultural	2.13	3.10	2.07	2.02	2.15	2.10
S.Em.±	0.09	0.08	0.07	0.08	0.66	0.05
C.D. at 5%	0.35	0.33	0.27	0.33	2.66	0.21

Table 2. Weed dry weight (g 0.25 m^{-2} 65 DAT/DAS) as affected by weed control treatments in different crops in rice-mustard-mungbean cropping system

Treatments	1997-98			1998-99		
	Rice	Mustard	Mungbean	Rice	Mustard	Mungbean
Weedy check	15.75	6.30	4.49	15.08	6.09	4.63
Handweeding	2.25	2.36	2.23	2.68	2.21	2.20
Chemical	5.35	2.88	2.53	5.40	3.04	2.52
Cultural	7.25	3.31	2.91	6.83	3.57	2.73
Chemical+Cultural	2.35	2.19	2.12	2.60	2.11	2.02
S.Em.±	0.14	0.04	0.05	0.14	0.05	0.05
C.D. at 5%	0.56	0.18	0.21	0.56	0.18	0.18

competition by other species was not apparent as their population was exiguous. In weed control treatments weed population and weed dry weight were significantly lower compared to weedy check. The lowest was recorded in chemical + cultural. The next best treatment was handweeding. Effect of weed control treatments in arresting weed population and weed dry weight was identical in both the years. The findings of Pandey and Thakur (1988), Srinivasan *et al.* (1992) were similar. They also recorded lower weed population and weed dry weight under weed control treatments.

The weed species that occurred in mustard were *Phalaris minor, Chenopodium album, C. murate, Fumeria perviflora* and *Spergula arvensis*. Weed control treatment brought about significant decrease both in weed population and in weed dry weight. Differences among weed control treatments were significant. Under weed control treatments weed dry weight differed significantly but differences were not wide. Pandey (1980) and Brar *et al.* (1991) reported that under weed control treatments weed population and weed dry weight was markedly lower.

In mungbean *Trianthema portulacastrum* was rampant. Other weed species of significance were *Cyperus rotundus, Echinochloa colonum, Digera arvensis* and *Amaranthus viridis*. Both weed population and weed dry weight were markedly lower under weed control treatment (Tables 1 and 2). Almost identical decrease occurred in hand weeding and chemical + cultural treatments as compared to other treatments. Cultural alone was least effective in arresting weed population and weed dry matter. The finding is in conformity of the finding of Singh (1976).

Effect of weed control treatments on grain yield of crops

Weed competition on an average brought down the total grain production of this system by 32% while that of rice, mustard and mungbean 35.3%, 19.3% and 45.6%, respectively. All the weed control treatments effected significant increase in grain yield of crops in both the years (1997-98 and 1998-99). However, there effect was not alike in both the years on grain yield of crops (Table 3).

In rice, in both the years the grain yield increase was significantly lower in cultural treatment compared to hand weeding, chemical and chemical + cultural treatments. In both the years chemical + cultural treatments brought about marked increase in grain yield. In first year (1997-98), it proved significantly superior to chemical but was statistically at par with handweeding. The latter treatment resulted in higher increase but was statistically at par with chemical treatment. In the second year of study (1998-99) grain yield under hand weeding, chemical and chemical + cultural was similar to that of first year (1997-98) but they did not differ significantly among themselves. Variation in yield increase in different treatments may be ascribed to their differential effect on weed population and weed biomass. Similar effect of weed control treatments on grain yield were reported by Pandey and Singh (1981), Pandey and Thakur (1988) and Paliwal *et al.* (1994). Chemical + cultural treatment caused maximum decrease in weed population and weed dry weight indicating thereby minimum crop weed competition. This might have helped the crop to express fully and yield higher in comparison to other treatments. Slightly lower increase in hand weeding compared to chemical + cultural treatment may be attributed to competitive effect exerted by weeds those emerged after hand weeding 35 days after. The findings of Prusty *et al.* (1993) were similar. Comparatively lower increase in yield in chemical treatment may be assigned to relatively higher weed population and weed dry weight. Weeds 25 days after anilofos application emerged, grew and accumulated considerable dry matter, inflicted crop resulting thereby in proportionately lower increase in grain yield. Pandey and Singh (1981) and Srinivasan *et al.* (1992) reported that rice grain yield increase in chemical treated plot was lower than hand weeded plots. Unchecked weed growth brought down the crop yield by 35.3%. Paliwal *et al.* (1994) also found 37.5% decrease in grains in transplanted rice.

Effect of weed control treatments was

Table 3. Yield of different crops (q ha^{-1}) as affected by weed control treatments in rice-mustard-mungbean cropping system

Treatments	1997-98			1998-99		
	Rice	Mustard	Mungbean	Rice	Mustard	Mungbean
Weedy check	33.83	12.30	2.54	31.79	12.50	3.32
Handweeding	49.61	15.80	4.84	47.42	15.70	4.91
Chemical	44.53	16.50	3.94	45.93	16.70	4.39
Cultural	35.16	15.00	3.05	34.30	14.60	4.03
Chemical+Cultural	52.11	14.60	5.20	49.32	15.00	5.58
S.Em.±	2.11	0.75	0.24	1.87	0.85	0.21
C.D. at 5%	6.23	2.19	0.72	5.6	2.54	0.63

Rice-anilofos, Wheat-isoproturon, Mungbean-pendimethalin

evident on grain yield of mustard in both the years of study. All the weed control treatments caused significant increase in yield but they did not differ significantly among themselves. The finding is in conformity with the finding of Brar *et al.* (1991). In contrast to rice and mungbean, mustard was less affected due to weed competition. On an average yield loss due to weed competition was 19.3% which was 1.66, 1.83 and 2.36 times lower than total grain productivity, rice and mungbean productivity, respectively. The lower yield loss may be ascribed to its suppressive effect on weeds. As it grows very fast 15 days after emergence, develops large canopy in short period and cover the ground that does not allow weeds to grow vigorously.

Effect of weed control treatments on grain yield of mungbean was well marked in both the years (1997-98 and 1998-99). In the first year (1997-98) chemical + cultural and hand weeding did not differ significantly between themselves but resulted in significantly higher increase in grain yield than chemical and cultural treatments. Increase in latter treatment was significantly lower than chemical but significantly higher than weedy check. In second year (1998-99) chemical + cultural treatment effected maximum increase and proved statistically superior to all other treatments. Hand weeding caused significantly higher increase compared to cultural treatment but it was statistically at par with chemical treatment. No significant existed between chemical and cultural treatment. The maximum increase in chemical + cultural treatment may be ascribed to reduced weed competition as evident by lower weed population and weed dry matter (Tables 2 and 3). Similar results were reported by Singh (1974). Prasad *et al.* (1989) reported that mungbean grain yield was higher in the plots where weed competition was lower.

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EFFECT OF NITROGEN ON CROP BIOMETRICS OF WHEAT

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ABSTRACT

Experiment was conducted to evaluate the effect of N application rate on the chlorophyll content, dry biomass of whole plant and plant height of winter wheat (HD 2285), late sown, so that the potential of these characters for the prediction in N fertilizer management can be judged. Chlorophyll content, dry weight and plant height were found to be positively correlated with nitrogen levels up to 125 kg/ha, after which for 150 kg/ha N rate, a decrease in these biometrics were found.

Key words : Nitrogen, chlorophyll, dry matter, plant height, wheat.

Nitrogen is the most important among all the sixteen essential elements required for the plant growth and directly influence the vegetative growth of the plants. Nitrogen is known to have significant effect on grain yield of the crops. Nitrogen caused changes in the histological, physiological and morphological characters on wheat crop (Fatyga *et al.* 1994; Arriaza *et al.* 1994; Jain *et al.* 1999). Shadchina and Dmitrieva (1995) found close relationship between chlorophyll in leaves, accumulation of total N and dry matter of the whole plant. Chlorophyll content is found to be an informative parameter for the estimation of N uptake from the soil. Some plant traits can be used as diagnostic tool in the optimization of nitrogen fertilizer management (Mambelli *et al.*, 1997). Therefore, the present study was undertaken to evaluate the effect on N application rate on the chlorophyll content, plant height and dry matter production of whole plant of wheat, so that the potential of these characters for the prediction in nitrogen fertilizer management can be judged.

MATERIALS AND METHODS

HD 2285 cultivar of wheat (late sown) was sown on 20th December 2000 in the Research Farm of Indian Agricultural Research Institute, New Delhi using randomized block design to study the effect of nitrogen treatment on the chlorophyll and growth of wheat crop. Five nitrogen treatments (0, 50, 75, 100, 125 and 150 kg/ha), in three replicated plots were given. Each plot receiving constant dose of P_2O_5 (60 kg/ha) and K_2O (40 kg/ha).

For the estimation of chlorophyll contents, green leaves were collected from each plot at 10 days interval from 30 Days after sowing (DAS) of crop. From the fresh leaves collected 50 mg material was taken and cut into small pieces and was put in 10 ml DMSO (Dimethyl Sulphoxide). The test tubes were then kept in oven at 65°C for 4 hours. The OD values were then taken at 645 nm and 663 nm using spectrophotometer. The amount of chlorophyll a and b and total chlorophyll were calculated using equation given by Arnon (1949).

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For the dry biomass, two plants were uprooted per plot randomly. The sampling was done at 10 days interval after 30 days of sowing. The plants were then dried at 70°C in an oven for one week or till constant weight was obtained. Weight of each plant was then recorded.

For the plant height of crop, 5 plants per plot were selected randomly and their height was measured with the help of measuring stick and averaged for per plant height.

RESULTS AND DISCUSSION

The chlorophyll content is found to be significantly correlated with the nitrogen dose ($r>0.8200$ at 5% probability level) at all the growth stages. The chlorophyll contents increases with increase in the nitrogen from 0 to 125 kg/ha. Jain *et al.* 1999 also reported that chlorophyll content of Kalyansona, wheat variety decreased at the optimal dose. However, Leake *et al.* 1997 found weak correlation between chlorophyll content of rice plant and soil mineral nitrogen. Further increase in nitrogenous fertilizer dose (150 kg/ha) resulted in the decrease in the chlorophyll content at all growth stages. Regression equation obtained between nitrogen dose and chlorophyll content at different growth stages are as follows :

Total Chl = 1.6353 + 0.0066 N
(For 30 DAS)

Total Chl = 3.2667 + 0.0012 N
(For 80 DAS)

Total Chl = 2.0621 + 0.0064 N
(For 110 DAS)

Total biomass on 80 DAS in the control plot was 1.52 g per plant. There was an increase in the dry biomass per plant as the nitrogen rate increases from 0 to 125 kg/ha (Table 1). No significant difference was found at 150 kg/ha nitrogen rate. Statistical analysis revealed that dry biomass was significantly correlated to nitrogen application rate ($r=0.9733$ at 0.001 probability level) at 80 DAS. An equation relating the dry biomass and nitrogen rate at anthesis stage of wheat plant was calculated and given below :

Dry biomass = 1.5279 + 0.0019 N

The dry biomass of the plant was expected to increase with the increase in nitrogen availability because of the close correlation between chlorophyll in leaves, accumulation of total nitrogen and dry biomass of the whole plant.

Plant height as affected by nitrogen application rate is given in Table 1. Plant height was found to be sensitive to nitrogen level ($r = 0.9782$ at 0.002 probability level) according to the equation.

Table 1. Effect of different nitrogen levels on different crop biometrics at 80 DAS of wheat

Nitrogen (kg/ha)	Total leaf chlorophyll (mg/gm)	Dry biomass (g/plant)	Plnat height (cm)
0	3.13	1.52	77.2
50	3.56	1.61	81.7
75	4.00	1.68	84.3
100	4.28	1.75	86.6
125	4.42	1.79	89.4
150	4.39	1.78	89.5

Plant height = 77.49 + 0.875 N.

All the crop biometrics selected for the present investigation was found to be sensitive for different nitrogen levels.

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EFFECT OF CONTROLLED RELEASE NITROGEN (CRN) UREA ON LONG DURATION TRANSPLANTED RICE (*ORYZA SATIVA* L.) UNDER HUMID TROPICAL CONDITIONS OF BAY ISLANDS

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ABSTRACT

A field experiment was conducted during the rainy (kharif) season of 2000 and 2001 to study the effect of controlled release nitrogen (CRN) on long duration transplanted rice (C14-8) under humid tropical condition of Bay Islands. The results revealed that application of CRN urea (6.0%) @ 60 per cent of recommended dose of N registered taller plants, higher dry matter production at harvest, number of panicles/hill and filled grains/panicle. It also registered higher grain yield of 2911 and 2945 kg/ha and net returns of Rs. 10369 and 9949/ha in 2000 and 2001, respectively, B:C ratio, lower specific energy and better energy use efficiency. However, it was on par with CRN urea (4.5%) @ 60% recommended dose for all the parameters.

Key words : CRN urea, long duration variety, yield, economics, energetics.

Being situated in a humid tropical zone Bay islands receive annual rainfall of 2960 mm spread over eight months starting from May. Though rice is the major field crop grown in these islands, farmers cultivate a traditional long duration rice cv. C 14-8 owing to continuous rainfall. The rice crop grown in the wet season usually recovers only 30-40 per cent of applied nitrogen (Prasad and De Datta, 1979), the rest being lost by way of denitrification, ammonia volatilization, leaching, run off and immobilization (Mohanty and Mandal, 1989). Recent research has indicated significant increase in yield by using slow release fertilizers. Controlled Release Nitrogen urea a slow release N fertilizer releases nitrogen gradually because of high coating strength and lower immobilization loss of available nitrogen and results in higher nitrogen use efficiency by the crop (Singh *et al.*, 1993; Singh and Singh, 1994). Hence at attempt was made to study the effect of CRN urea on the growth, economics and energetics of long duration transplanted rice.

MATERIALS AND METHODS

The experiment was conducted in the wet season (kharif) of 2000 and 2001 at the Bloomsdale farm of Central Agricultural Research Institute, Port Blair. The soil of the experimental site was a sandy clay loam with pH 5.59, organic carbon 0.58%, available N 210 kg, P_2O_5 12 kg and K_2O 110 kg/ha. Six treatments were laid out in 4×2.5 m net plots arranged in randomized block design with four replications. The treatments were : T_1, No nitrogen; T_2, recommended N as urea (basal, 30th and

70th DAP); T_3, recommended N as urea (no basal, 30th and 70th DAP); T_4, recommended N as urea (basal, 30th, 70th DAP and 25 kg/ha at panicle initiation stage); T_5, controlled release nitrogen (CRN) urea (4.5%) @ 60% of the recommended dose and T_6, controlled release nitrogen (CRN) urea (6.0%) @ 60% of the recommended dose. The recommended dose of NPK adopted was 90:60:40 kg/ha. Nitrogen was applied as per the treatment, while P and K were applied basally. CRN urea (4.5 and 6.0%) @ 60% of the recommended N dose was applied before last puddling and incorporated into the soil. Long duration traditional variety of these islands C 14-8 with duration of 160 to 170 days was selected for the study and 30 days old seedlings were transplanted during August with a spacing of 20 × 15 cm in both the years. All the recommended package of practices for C 14-8 rice variety was adopted. Observation on growth, yield attributes and yield were recorded as per the standard procedure. Economics and energetics were calculated, basal on the methods described by Mittal *et al.* (1985).

RESULTS AND DISCUSSION

Growth attributes

Plant height and dry matter production at harvest increased significantly with the application of CRN urea over the rest of the treatments. CRN urea (6.0%) @ 60% of recommended dose registered taller plants (182.4 and 175.8 cm respectively in 2000 and 2001) and dry matter production at harvest (12736 and 13412 kg/ha in 2000 and 2001 respectively). However, it was on par with CRN urea (4.5%). All the other treatments registered significantly shorter plants and lower dry matter production at harvest. The enhancement in growth parameters with CRN urea was due to continued supply of nitrogen, which would have enhanced rapid conversion of synthesized carbohydrates in to protein to form more protoplasm with a subsequent increase in number and size of cell causing an increase in dry matter. The results confirm the findings of Yadav *et al.* (1995).

Table 1. Influence of CRN urea on growth and yield attributes of long duration rice

Treatments	Plant height at harvest (cm)		DMP at harvest (kg/ha)		Number of panicles/hill		Number of filled grains/panicle	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1	158.9	152.7	9169	8344	2.8	2.6	74.0	69.5
T_2	160.2	154.3	10023	9947	3.6	3.0	83.8	80.5
T_3	160.6	155.6	10942	10592	4.1	3.3	84.7	82.6
T_4	163.2	158.4	12132	12542	4.5	3.8	87.8	86.9
T_5	181.6	176.4	12601	12921	5.2	4.6	93.2	90.5
T_6	182.4	175.8	12736	13412	5.3	4.7	95.6	91.7
C.D. (5%)	2.8	3.1	372	496	0.20	0.26	4.7	5.3

Table 2. Effect of CRN urea on yield, net return and B : C ratio of long duration rice

Treatments	Grain yield (kg/ha)		Straw yield (kg/ha)		Net returns (Rs/ha)		B:C ratio	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1	2086	1985	6983	6286	5436	5211	0.98	0.92
T_2	2293	2276	7676	7670	7313	6986	1.26	1.27
T_3	2391	2321	8477	8229	7546	7215	1:27	1.25
T_4	2650	2611	9395	9842	9085	8896	1.45	1.40
T_5	2876	2821	9628	10002	10158	9896	1.63	1.61
T_6	2911	2945	9746	10441	10369	9949	1.64	1.62
C.D. (5%)	181	204	392	347	-	-	-	-

Yield attributes

Application of CRN urea significantly influenced the yield attributes viz., number of panicles/hill and filled grains/panicle. CRN urea (6.0%) @ 60 per cent of recommended dose of N resulted in higher number of panicles/hill (5.3 and 4.7 in 2000 and 2001, respectively) and filled grains/panicle. However, it was on par with T_5. Application of N as urea in four splits (T_4) registered significantly lower number of panicle/hill and filled grains/panicle compared to CRN urea. The improvement in yield attributes due to CRN urea application may be ascribed to slow releasing and denitrification inhibiting character, which offered steady availability of nitrogen throughout crop growth period. The results corroborated with the findings of Sharma and Chauhan (1993) and Singh *et al.* (1993).

Yield

The grain and straw yields were significantly higher with the application of CRN urea compared to normal urea. CRN urea (4.5 and 6.0%) registered 8.3 and 11.3% higher grain yield respectively compared to urea applied in four splits (T_4). All the other treatments registered significantly lower grain yield including control (T_1), which recorded pooled grain yield of only 2036 kg/ha. The straw yield also registered a similar trend. Higher yield under CRN urea might be attributed to improved growth and yield attributes as a consequence of slow release and nitrification-inhibiting character of CRN urea as reported by Singh *et al.* (2000).

Economics

Similar to the grain and straw yield, CRN urea (4.5 and 6.0%) @ 60% of recommended dose registered higher net returns (Rs. 10027 and 10159/ha) and B : C ratio (1.62 and 1.63) in first and second year, respectively. All the other treatments recorded lower net returns and B : C ratio which confirms the findings of Mishra *et al.* (2000).

Economics

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Energetics

Energy parameters viz., specific energy and energy use efficiency were highly influenced by the CRN urea T_6 registered lower specific energy of 3.34 and 2.85 MJ kg/ha and higher energy use efficiency of 8.78 and 9.80 in 2000 and 2001, respectively. However, it was closely followed by T_5. All the other treatments had higher specific energy and lesser EUE. Similar findings on energetics have been reported by Bhuvaneswari (1998).

Thus, from the study it can be concluded that CRN urea (4.5 and 6.0%) @ 60% of the recommended dose of nitrogen can be applied for realizing better growth, yield attributes, yield, economics and energetics of long duration transplanted rice (C14-8) under humid tropical conditions of Bay islands.

Table 3. Effect of CRN urea on energetics of long duration transplanted rice

Treatments	Specific energy (MJ/kg)		EUE	
	2000	2001	2000	2001
T_1	6.72	4.12	5.22	5.52
T_2	4.68	3.39	6.82	7.05
T_3	4.27	2.97	7.65	7.88
T_4	3.63	2.74	8.61	9.13
T_5	3.55	2.79	8.62	9.63
T_6	3.34	2.85	8.78	9.80

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HETEROSIS FOR YIELD AND ITS COMPONENTS IN MUSKMELON (*CUCUMIS MELO* L.)

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ABSTRACT

Eight parental lines and 28 F_1 hybrids of muskmelon obtained from half diallel were studied to investigate the extent of heterosis for yield and its contributing characters. M_3 (P_4), DMDR-1 (P_5) and Hara Madhu (P_8) were observed to be three top performing parents for average yield per plant. Appreciable heterosis was recorded over top parent and commercial check (Punjab hybrid) for all the characters studied except vine length. In order to merit, F_1 hybrid $P_4 \times P_5$ (M_3 × DMDR-1), $P_2 \times P_5$ (Pusa Madhuras × DMDR-1) and $P_2 \times P_8$ (Pusa Madhuras × Hara Madhu) were observed to be three best performing F_1 hybrids for average yield per plant.

Key words : Half diallel, heterosis, yield, muskmelon.

Muskmelon is one of the valued summer fruits because of tis nutritive, demulcent diuretic medicinal value, taste, flavour, sweetness and aroma. Inspite of wide range of genetic variation in respect of earliness, number, weight, colour, shape, size and flavour of the fruits, very little attention has been given to exploit it. Thus, there is good scope for improvement of yield and other desirable characters through heterosis breeding. The study reported here was designed to gather information on the extent of heterosis through 8×8 diallel for yield and its contributing components in this crop.

MATERIALS AND METHODS

The experiment was carried out at Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi during summer 1999-2000 to 2000-2001. Eight diverse inbreeds of muskmelon namely DVRM-1 (P_1) Pusa Madhuras (P_2), Punjab Rasila (P_3), M_3 (P_4), DMDR-1 (P_5), Durgapura Madhu (P_6), Ravi (P_7) and Hara Madhu (P_8) were crossed in all possible combination excluding reciprocals. The 28 F_1 hybrids along with eight parental lines set were grown in randomized block design with three replications. The crop was planted in rows of 2.5 meters apart with a spacing of 0.60 m between plants. The observations were recorded on five plants for ten characters namely, node number of first female flower, days to first female flower opening, days to first fruit maturity, Number of fruits per plant, fruit weight (kg), Fruit diameter (cm), flesh thickness (cm), fruit cavity (cm), average yield per plant (kg) and vine length (cm). Heterosis was calculated as the percentage of F_1 performance in the favourable direction over top parent and commercial check (Punjab Hybrid) for each character.

RESULTS AND DISCUSSION

Performance of 8 parental lines and 28 F_1 hybrids is given in Table 1. Among all the parents, the parent P_6 (Durgapura Madhu) had the lowest node number and days to first female flower opening. P_3 (Punjab Rasila) was observed to be the earliest for days to first fruit harvest followed by P_1 (DVRM-1) and P_6 (Durgapura Madhu). The highest number of fruits per plant was recorded by P_4 (M_3) followed by P_7 (Ravi) and P_8 (Hara Madhu). The highest fruit weight was observed in parent P_5 (DMDR-1) followed by P_4 and P_8. The parent P_4 (M_3) gave the highest average yield per plant followed by P_5 and P_8. Maximum fruit diameter and flesh thickness was observed in P_4 (M_3). The longest vine length was observed P_8 (Hara Madhu) and the shortest vine length in P_6 (Durgapura Madhu). Minimum fruit cavity was observed in P_6 (DMDR-1). In order of merit, P_4 (M_3), P_5 and P_8 (Hara Madhu) were found to be three top performing lines for average yield per plant and they produced yield of 3.77, 3.39 and 2.70 kg per plant, respectively.

Range of mean values of parents, F_1 hybrids and per cent heterosis are given in Table 2. The mean of F_1 crosses were lower than those of the parents for node number of first female flower, days to first female flower opening, days to first fruit maturity and vine length. The mean of F_1 crosses were higher than those of parents for number of fruits per plant, fruit weight, fruit diameter, flesh thickness, fruit cavity and average yield per plant. The range of heterosis percentage of F1 hybrids over top parent and commercial check varied from nil and -8.60 to -48.00 for node number of first female flower, nil and -0.03 to -11.58 for days to first female flower opening, nil and -1.39 to -3.45 for days to first fruit maturity, 0.28 to 24.51 and 0.55 to 22.47 for number of fruits per plant, 2.50 to 24.16 and 0.86 to 22.41 for fruit weight, nil and nil for fruit diameter, 2.47 to 9.54 and 1.05 to 8.01 for flesh thickness, -3.10 to -3.26 and -1.87 to -14.92 for fruit cavity, 0.24 to 50.35 for average yield per plant, nil and 3.87 to 6.99 for vine length, respectively.

Out of 28 F_1 hybrids, the heterotic effects over top parent and commercial check were observed in one and four for node number of first female flower, one and found for days to first female flower opening, one and two for days to first fruit maturity, nine and six for number of fruits per plant, six and six for fruit weight, one and one for fruit diameter, two and two for flesh thickness, two and four for fruit cavity, nine and five for average yield per plant, zero and tree for length.

The best performing hybrids along with their heterosis percentage over top parents for different characters included $P_4 \times P_6$ (M_3 × Durgapura Madhu) for node number of first female flower (-7.14) and days to first female flower opening (-3.85), $P_1 \times P_7$ (DVRM-1×Ravi) for days to first fruit

Table 1. Performance of parental lines and F1 hybrids of muskmelon

Parents	Node No. of first female flower	Days to first female flower opening	Days to first fruit maturity	No. of fruits per plant	Fruit weight (kg)	Fruit diameter (cm)	Flesh thickness (cm)	Fruit cavity (cm)	Average yield per plant (kg)	Vine length (cm)
P_1 (DVRM-1)	4.47	42.02	78.52	2.34	0.53	10.37	1.77	7.53	1.25	145.77
P_2 (Pusa Madhuras)	7.40	49.26	83.62	3.13	0.85	12.73	2.63	7.20	2.66	239.77
P_3 (Punjab Rasila)	7.60	51.63	76.16	2.65	0.67	11.07	1.93	7.70	1.77	159.57
P_4 (M_3)	8.50	57.36	90.30	3.59	1.06	14.00	2.83	7.93	3.77	176.06
P_5 (DMDR-1)	8.17	53.38	88.17	2.96	1.14	13.30	21.73	6.63	3.39	216.52
P_6 (Durgapura Madhu)	2.80	38.74	79.53	2.74	0.55	7.33	1.90	6.13	1.49	131.07
P_7 (Ravi)	7.00	45.59	81.25	3.25	0.78	12.47	2.37	7.40	2.52	190.61
P_8 (Hara Madhu)	10.50	62.12	96.13	3.03	0.89	12.63	2.50	7.03	2.70	263.76
F_1 hybrids										
$P_1 \times P_2$	7.50	50.02	84.71	2.56	0.63	7.30	1.30	7.00	1.59	155.59
$P_1 \times P_3$	7.70	51.76	86.93	2.70	0.73	10.37	1.47	7.33	1.95	165.61
$P_1 \times P_4$	8.57	58.38	91.42	3.00	0.76	13.10	1.57	8.13	2.27	160.85
$P_1 \times P_5$	3.60	41.29	77.36	2.76	0.68	13.07	1.97	7.93	1.87	172.89
$P_1 \times P_6$	4.57	45.75	79.25	2.72	0.58	9.37	1.33	7.20	1.58	144.04
$P_1 \times P_7$	3.50	39.97	76.06	2.84	0.82	12.60	2.00	7.67	2.31	161.44
$P_1 \times P_8$	7.53	59.54	90.53	3.13	0.86	12.83	2.10	7.37	2.70	201.32
$P_2 \times P_3$	7.70	52.61	87.30	2.53	0.72	10.73	1.27	7.40	1.81	185.73
$P_2 \times P_4$	8.60	58.12	91.19	2.56	0.66	9.73	1.37	8.03	1.69	190.87
$P_2 \times P_5$	5.50	47.37	81.72	4.02	1.31	13.70	2.83	7.53	5.30	244.99
$P_2 \times P_6$	6.50	48.40	81.51	2.85	0.76	7.33	1.27	5.93	2.15	139.11
$P_2 \times P_7$	6.07	43.34	78.63	3.95	0.94	13.00	2.70	7.60	3.72	208.64
$P_2 \times P_8$	6.53	47.55	81.86	4.15	1.18	13.27	2.77	7.63	4.90	252.35

Contd...

Table 1. Contd...

$P_3 \times P_4$	7.10	50.98	84.96	3.61	1.12	13.90	2.57	8.13	4.04	161.80
$P_3 \times P_5$	6.60	49.29	83.93	3.53	1.17	11.57	2.03	7.17	4.13	171.30
$P_3 \times P_6$	6.73	42.12	82.06	3.12	0.74	11.13	1.97	7.33	2.31	141.15
$P_3 \times P_7$	6.03	43.48	78.52	3.87	0.82	11.14	2.10	7.30	3.16	201.90
$P_3 \times P_8$	7.03	50.71	85.55	2.66	0.69	9.50	1.40	6.83	1.82	181.00
$P_4 \times P_5$	7.27	51.30	86.81	4.47	1.42	15.07	3.10	6.84	6.36	189.19
$P_4 \times P_6$	2.60	37.25	78.47	3.64	1.09	10.43	2.50	7.63	3.97	164.27
$P_4 \times P_7$	7.97	48.78	84.02	3.60	1.17	13.30	2.90	8.13	4.24	208.56
$P_4 \times P_8$	8.80	58.30	91.40	2.82	0.67	8.87	1.43	7.33	1.89	250.55
$P_5 \times P_6$	8.60	54.19	88.77	3.41	1.19	10.57	1.55	7.00	4.06	151.95
$P_5 \times P_7$	5.53	42.38	77.78	3.67	1.20	13.27	2.47	7.57	4.40	218.51

maturity (-0.13), $P_4 \times P_5$ ($M_3 \times$ DMDR-1) for number of fruits per plant (24.51), fruit weight (24.00), fruit diameter (7.64), flesh thickness (9.54) and average yield per plant (68.57) and $P_2 \times P_6$ (Pusa Madhuras × Durgapura Madhu) for fruit cavity (-14.92). None of the F hybrids, nine were found superior top parent P_4 (M_3). In order of merit, F_1 hybrids $P_4 \times P_5$, $P_2 \times P_5$ and $P_2 \times P_8$ were observed to be three best performing hybrids for average yield per plant and they showed significant heterosis of 68.57, 56.34 and 44.54 per cent, respectively over top parent P_4 (M_3). The highest yield recorded by the best performing F_1 hybrid $P_4 \times P_5$ could be attributed to increase number of fruit per plant, fruit weight, fruit diameter and flesh thickness. The results of present study are in conformity with the findings of More and Seshadri (1980), Munshi and Verma (1997) in muskmelon, Kale and Seshadri (1981), Rajendran and Thanmburaj (1993) in watermelon and Singh et al. (2000) in bittergourd. The results from the present study suggest that from economic point of view, it is useful to select parental lines having one or more important characters like higher fruit number, fruit weight, fruit diameter and flesh thickness associated with high yield in order to achieve higher gains in the F_1 hybrids through exploitation of heterosis.

The best performing F_1 hybrid $P_4 \times P_5$ ($M_3 \times$ DMDR-1) which recorded 68.57 and 50.35 per cent higher yield over top parent and commercial cultivation.

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GROWTH PARAMETERS, YIELD ATTRIBUTES AND YIELD OF PIGEONPEA AS INFLUENCED BY CROPPING SYSTEMS AND NITROGEN + PHOSPHORUS LEVELS

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ABSTRACT

A field experiment was conducted to study the effect of cropping systems on pigeonpea. The growth parameters viz., plant height, dry matter production, and leaf area index recorded higher values in 1:1 row ratio than 2:2 row ratio of pigeonpea + maize intercropping system. Though intercropping with maize brought significant decline in these parameters. Similar trend was observed in yield and yield attributes viz., branches per plant, number of pods per branch, pod length, weight per pod, number of grains per pod, weight of grains per pod and 1000 grain weight. Nitrogen + phosphorus application significantly improved the growth parameters, yield attributes and yield of pigeonpea only upto 100 per cent of recommended dose.

Key words : Cropping systems, growth parameters, yield attributes, pigeonpea, nitrogen + phosphorus, maize.

Among the pulse crops, pigeonpea is the most important kharif pulse crop of India. Pigeonpea is an eminently suitable pulse crop for intercropping as it is grown in rows which are usually wider than those in other kharif pulses. The evolution of new cultivars embodying compact plant type and shorter duration have added new dimensions to the production of this important pulse crop in India. It is known that pigeonpea makes very slow growth during the first 60-70 days. It also provides sufficient inter-row space which can be profitably utilized for raising short duration cereal crop like maize. Nutrient requirement of pigeonpea in intercropping may be different. Therefore, the response of pigeonpea to nitrogen + phosphorus levels under intercropping system needs to be examined.

MATERIALS AND METHODS

The field experiment was conducted during 1996-97 at Agronomy research farm of Indian Agricultural Research Institute, New Delhi. The soil of the experimental field was of yamuna alluvial origin and was sandy clay loam in texture with adequate internal drainage. The soil was low in organic carbon and available nitrogen. The status of available phosphorus was medium with high exchangeable potassium. The experimental treatments consisting of three cropping systems (pigeonpea - sole, pigeonpea + maize - 1:1 and pigeonpea + maize - 2:2 row ratio) in main plot and four levels of nitrogen + phosphorus (control, 50, 100 and 125 per cent of recommended dose) in subplot, were laid out in split plot design with three replications. All other recommended cultural practices were adopted to raise the crops. Soil samples were taken before sowing and after harvesting of crop for characterizing physico-chemical properties of soil. Plant samples were taken from sampling row at 30, 60, 90 days after sowing and at harvest. The mean maximum and minimum temperature recorded during the crop season were 35.5°C and 5.6°C respectively.

RESULTS AND DISCUSSION

Growth parameters

It was observed that the plant height, LAI and dry matter production in sole pigeonpea registered an increase as compared to 1:1 and 2:2 pigeonpea + maize row ratio almost at all the crop growth stages (Table 1). The reduction in these growth parameters due to intercropping of pigeonpea with maize in both the row ratios might be due to more competition caused by maize for light, water, space and nutrients etc. Further, slow early growth of pigeonpea provided an opportunity for presumably early vigorous growth of maize which, in turn, led to a decline in plant height, dry matter accumulation and LAI of pigeonpea when intercropped with maize either in 1:1 or 2:2 row ratio. The reduced leaf area relatively resulted in less accumulation of photosynthates. Therefore, the plant height and dry matter production by pigeonpea + maize in 1:1 and 2:2 row ratios showed a decline. These findings are in line with those obtained by Thakur and

Table 1. Effect of cropping systems and nitrogen + phosphorus levels on growth parameters of pigeonpea

Treatments	Plant height (cm)			Dry matter production (g/plant)				Leaf area index		
	30DAS	60DAS	90DAS	Atharvest	30DAS	60DAS	90DAS	Atharvest	30DAS	60DAS	90DAS	Atharvest
Cropping systems												
Pigeonpea sole	47.42	111.12	171.65	181.73	8.21	15.13	35.54	63.82	0.479	0.783	1.367	0.919
Pigeonpea+maize-1:1	42.77	106.96	166.40	175.33	7.13	14.03	33.85	61.72	0.474	0.776	1.245	0.902
Pigeonpea+maize+-2:2	42.52	106.35	164.33	174.30	7.08	13.63	33.64	61.52	0.471	0.774	1.159	0.861
S.Em.±	0.32	1.187	2.05	1.74	0.08	0.11	0.31	0.687	0.005	0.007	0.014	0.008
C.D. (P=0.05)	1.05	3.87	6.69	6.68	0.26	0.341	1.01	2.23	NS	NS	0.044	0.027
Nitrogen + Phosphorus levels												
Control	38.58	101.67	156.31	166.54	6.24	11.57	30.92	57.49	0.407	0.722	1.143	0.793
50% of recommended	38.58	101.67	156.31	166.54	7.26	13.87	33.81	61.61	0.479	0.775	1.276	0.869
100% of recommended	43.22	106.90	165.93	175.88	8.04	15.57	35.87	64.56	0.506	0.805	1.301	0.852
125% of recommended	48.29	112.60	174.26	183.62	8.37	16.06	36.78	65.74	0.508	0.808	1.301	0.963
S.Em.±	0.34	1.23	2.10	1.78	0.09	0.11	0.33	0.75	0.005	0.007	0.014	0.009
C.D. (P=0.05)	0.98	3.54	6.08	5.16	0.98	3.54	6.08	5.16	0.015	0.013	0.042	0.025

Sharma (1988).

Increasing fertilizer levels of N + P brought about a corresponding increase in growth parameters up to the application of 100 per cent recommended dose of N + P to sole pigeonpea presumably helped in cell division and enlargement and metabolic activities. Application of these nutrients to soil also made the soil environment favourable not only for their uptake, but also for other essential nutrient elements. This led to the overall improvement in growth and development of pigeonpea owing to application of full recommended dose of N + P.

It is well known that an increase in plant height and LAI tend to augment the magnitude of the assimilating surface per unit area. Thus, it may be stated that simultaneous increase in the light and functional leaves in a plant cause a substantial improvement in the production and accumulation of photosynthates due to higher applied fertility levels. Hence, it could be concluded that the plants receiving higher fertility levels (up to 100 per cent of recommended N + P) were favorably disposed of towards higher dry matter production. These findings are in close conformity with those of Khan (1988).

Yield attributes and yield

Yield attributes viz., branches per plant, number of pods per branch, pod length, weight per pod, number of grains per pod, weight of grains per pod and 1000-grain weight exhibited a significant decline when pigeonpea was intercropped with maize in 1:1 and 2:2 rows ratios (Table 2). The components of pigeonpea were adversely affected under intercropping system probably due to competition for both applied and natural growth and development resources. This view is corroborated by the observation on yield components of sole pigeonpea. Similar results have also been reported by Rafey (1992). Yield components of pigeonpea between 1:1 and 2:2 intercropping system did not differ significantly since both the systems faced the competition due to the associated maize crop. An overall reduction in growth, development and yield attributing characters as presented above had a cumulative effect causing a decrease in grain, stalk and biological yield in both of pigeonpea + maize intercropping systems. However, no significant difference was observed in the yield between 1:1 and 2:2 intercropping systems. These results are supported by those of Pujari *et al.* (1994) and Silim *et al.* (1995).

The cumulative effect of improvement in various growth parameters due to increasing nitrogen + phosphorus levels resulted in a significant increase in yield attributes of pigeonpea. The number of branches per plant and number of pods per branch depend on the growth of a plant. It is a fact that healthy and vigorous plants produced more number of healthy grains per pod. Results reported by Bisen *et al.* (1984) lend support to these observations summarized above.

All these growth, development and yield attributing characters cumulatively resulted in significant enhancement of grain, stalk and biological yield and harvest index of pigeonpea on account of increasing nitrogen + phosphorus levels (up to 100 per cent

Table 2. Effect of cropping systems and nitrogen + phosphorus levels on yield attributes of pigenopea

Treatments	No. of branches/ plant	No. of pods/ branch	Pod length (cm)	Weight/ pod	No. of grains/ pod	Weight of grains/ pod	100 grain weight	Grain yield (q/ha)	Stalk yield (q/ha)
Cropping systems									
Pigeonpea sole	11.65	8.72	5.39	0.395	3.658	0.282	78.156	18.73	52.41
Pigeonpea+maize-1:1	10.80	7.53	5.04	0.3785	3.325	0.263	69.617	14.21	36.65
Pigeonpea+maize+-2:2	10.80	7.53	5.04	0.372	3.308	0.259	69.599	13.94	35.81
S.Em.±	0.152	0.103	0.046	0.004	0.043	0.003	0.760	0.14	0.32
C.D. (P=0.05)	0.496	0.335	0.150	0.012	0.139	0.009	2.480	0.45	1.04
Nitrogen + Phosphorus levels									
Control	9.92	7.32	4.88	0.349	3.144	0.232	68.878	12.69	37.58
50% of recommended	10.84	7.71	5.03	0.375	3.389	0.261	72.645	14.53	41.17
100% of recommended	11.15	8.20	5.21	0.395	3.578	0.288	73.919	17.37	43.43
125% of recommended	11.37	8.40	5.33	0.405	3.611	0.291	74.388	17.87	44.30
S.Em.±	0.163	0.110	0.050	0.004	0.047	0.003	0.810	0.17	0.38
C.D. (P=0.05)	0.471	0.318	0.144	0.011	0.134	0.009	2.340	0.51	1.10

recommended). However, no significant improvement was observed between the yield obtained from the plots supplied with 100 and 125 per cent of the recommended dose of N + P. It could be assigned to the fact that there was no improvement in yield attributes due to the application of 125 per cent of the recommended dose of N + P. Identical observations have been made by Pujari *et al.* (1992) and Srivastava and Srivastava (1993).

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EFFECT OF CHEMICAL AND BIOFERTILIZERS ON YIELD AND NUTRIENT UPTAKE OF RICE IN ACID SOILS OF MIZORAM

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ABSTRACT

Field experiments were conducted to study the effect of different levels of N in combination with Blue Green Algae on yield and nutrient uptake of rice and changes in soil properties. The results revealed that grain yield and other yield attributes significantly increased with graded doses of N up to 80 kg N ha^{-1}. The average increase in the grain yield due to combined use of BGA with different levels of N (40, 80 and 120 kg ha^{-1}) was 5.07, 4.03 q/ha^{-1} during first year and 5.47, 5.22 and 3.57 q/ha^{-1} during second year in comparison to respective doses of N application. The content and uptake of N, P and K in grain significantly increased with the application of different levels of N either alone or in combination with BGA. Highest N recovery (55.4%) was recorded in both the cropping seasons with the combined use of 40 kg N ha^{-1} and BGA inoculation. After harvest of second crop of rice, the soil pH changed from 5.5 to 5.9 as affected by different treatments. Addition of BGA and fertilizer N showed positive changes in organic carbon and available N, P and K status of the soil. It could be concluded that integrated use of biofertilizer and application of 80 kg N ha-1 showed highest yield and uptake response and curtails the expenditure on fertilizer cost to an extent of 30-40 kg ha^{-1} besides improves the fertility status of soil.

Key words : Blue green algae, N levels, yield response, aparent N recovery, soil properties.

Rice is the staple food crop of Mizorum and supplies major portion of the dietary energy. It grows in an area of 0.51 lakh ha with a production of 1.04 lakh tonnes, according to the estimates of 2000-2001 (Anonymous, 2001). The total fertilizer consumption of the state accounted to be 0.25, 0.53 and 0.37 thousand tonnes of N, P_2O_5 and K_2O, respectively, as per the estimates of 1998-99. Low and imbalance use of NPK, lack of awareness, non adoption of modern technologies caused lower crop yields. Blue green algae, an important biofertilizer for rice cultivation and plays, vital role in integrated plant nutrient supply system to achieve sustained crop production and maintain soil health (Dixit and Gupta, 2000). The present investigation was planned to study the effect of different levels of N and in combination with biofertilizer (BGA) on yield performance and nutrient uptake of paddy and soil characteristics.

MATERIALS AND METHODS

Field experiments were conducted for

two consecutive *kharif* seasons of 2000 and 2001 on a Typic Hapludult at ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib. The experiment was laid out in three replications in a randomized block design with 8 treatments viz., Control, 40 kg N ha^{-1}, 80 kg N ha^{-1}, 120 kg N ha^{-1}, Blue green algae, 40 kg N ha^{-1} + BGA, 80 kg N ha^{-1} + BGA and 120 kg N ha^{-1} + BGA. A uniform dose of P_2O_5 @ 80 kg ha^{-1} and K_2O 60 kg ha^{-1} in the form of single super phosphate and muriate of potash, respectively were applied at basal. Calculated quantities of N in the form of urea was applied in three split doses (½ at basal, ¼ at tillering and ¼ at panicle initiation stage). Farmyard manure @ 10 t ha^{-1} was applied uniformly well in advance of transplanting of the crop. Rice (cv RCPL-1-87-4) seedlings were transplanted at two per hill at a spacing of 20×10 cm. The straw based culture of BGA was mixed with fine sand and broadcasted after transplantation in the respective treatments. The BGA contains *Anabaena variabilis, Nostoc muscorum, Aulosira fertilissima and Tolypothrix tenuis*. Appropriate management practices were adopted. The crop was harvested at maturity and yield parameters like no. of tillers/hill, no. of grains/panicle, 100 grain weight, grain yield and straw yield were recorded. Grain samples were dried in an oven and grounded. These samples were analysed for total N by micro kjeldahl method (Piper, 1966), total P by vanadomolybdophosphoric acid yellow colour method (Jackson, 1973) and total K by flame photometric method (Jackson, 1973). The soil samples were collected after harvest of second crop of rice, processed and analysed for physico-chemical properties by standard methods as described by Jackson (1973). The nutrient uptake was computed by multiplying nutrient content with grain yield. The per cent yield response, per cent uptake response and apparent N recovery were calculated as follows :

$$\text{Per cent yield response} = \frac{\text{Treatment yield(kg ha}^{-1}\text{)} - \text{Control yield (kg ha}^{-1}\text{)}}{\text{Control yield (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Per cent uptake response} = \frac{\text{Nutrient uptake in treatment} - \text{Nutrient uptake in control}}{\text{Nutrient uptake in control}} \times 100$$

$$\text{Apparent nutrient recovery (\%)} = \frac{\text{Nutrient uptake in treatment} - \text{Nutrient uptake in control}}{\text{Amount of nutrient applied}} \times 100$$

RESULTS AND DISCUSSION

Effect of nitrogen and BGA on yield parameters

The results in Tables 1 and 2 revealed that the grain and straw yields increased significantly with the increased doses of N application up to 80 kg ha^{-1} and showed positive response for higher doses i.e. 120 kg N ha^{-1}. Highest grain yield of 54.70 q

Table 1. Effect of different levels of N and in combination with BGA on yield parameters of paddy during *kharif*, 2000

Treatment	No. of tillers/ hill	No. of grains/ panicle	100 seed wt. (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
1. Control	5.5	130.9	2.39	3427	10833
2. 40 kg N ha^{-1}	7.6	153.6	2.58	4650	13240
3. 80 kg N ha^{-1}	8.9	166.6	2.64	5067	14580
4. 120 kg N ha^{-1}	9.4	162.2	2.69	5310	15757
5. Blue green algae	6.9	145.9	2.52	4370	12120
6. 40 kg N ha^{-1} + BGA	8.9	165.3	2.71	5157	15957
7. 80 kg N ha^{-1} + BGA	10.1	178.8	2.69	5470	15527
Mean	8.2	157.6	2.60	4779	14008
SEd	1.04	13.09	0.129	398.0	812.1
C.D. at 5%	1.85	23.34	0.230	709.3	1447.0

Table 2. Effect of different levels of N and in combination with BGA on yield parameters of paddy during *kharif*, 2001

Treatment	No. of tillers/ hill	No. of grains/ panicle	100 seed wt. (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
1. Control	6.7	123.2	2.72	3964	7243
2. 40 kg N ha^{-1}	7.0	133.8	2.82	4258	12431
3. 80 kg N ha^{-1}	8.3	145.6	2.89	4584	14757
4. 120 kg N ha^{-1}	8.5	143.8	2.90	4784	15337
5. Blue green algae	7.5	124.1	2.82	4017	11250
6. 40 kg N ha^{-1} + BGA	8.2	148.2	2.92	4804	14626
7. 80 kg N ha^{-1} + BGA	8.4	168.1	2.97	5106	14959
8. 120 kg N ha^{-1}	9.5	183.5	3.07	5142	16446
Mean	8.0	146.3	2.89	4570	13381
SEd	0.44	3.96	0.047	109.2	1182.8
C.D. at 5%	0.77	6.97	0.082	192.3	2082.9

ha^{-1} was recorded with the combined application of 80 kg N ha^{-1} and BGA inoculation during kharif 2000, while the grain yield was almost on par with the application of 80 and 120 kg N ha^{-1} along with BGA inoculation during kharif 2001. Inoculation with BGA and application of chemical fertilizer N showed significant increase in grain yield by 5.07 q ha^{-1} (11%), 4.03 q ha^{-1} (8%) during the first year and 5.47 q ha^{-1} (13%), 5.22 q ha^{-1} (11%) and 3.57 q ha^{-1} (7%) in comparison with the application of 40, 80 and 120 kg N ha^{-1}, respectively. However, the straw yield also significantly increased during both the years with the combined use of N and BGA in comparison to application of N alone. Yield parameters like No. of tillers/hill, No. of grain/panicle and test weight positively increased with the increased levels of N and

BGA inoculation along with fertilizer N showed positive response on all yield parameters. It was found that the grain yield was significantly increased with the inoculation of BGA during the first year as compared to control and non significant increase during the second year. Combined use of BGA and fertilizer N showed the fertilizer economy of 30-40 kg ha^{-1}. Comparable increase of yield due to inoculation of BGA either alone or in combination with N has also been reported by Mishra and Sharma (1997).

Nitrogen content and N uptake by grain

The N content in grain ranged from 0.740 to 1.20% and 0.780 to 1.193% with a mean value of 0.953 and 1.016% during first and second year, respectively (Table 3). There was a significant increase in N content with the increased levels of N application during both the years. Application of biofertilizer in combination with fertilizer N significantly increased the N content by grain as compared to application of N alone. Following the pattern of N content and yield, highest N uptake values in grain (65.38 and 61.33 kg ha^{-1}) during the first and second year, respectively were recorded with the combined use of BGA and fertilizer N. A significant increase in N uptake with the increased levels of N as well as in combination with BGA inoculation was observed during both the years. Increased content and uptake of N as a result of BGA inoculation is understood in view of its nitrogen fixing capacity. Positive effect of BGA on N content and its uptake by rice has also been reported by Dixit and Gupta (2000).

Phosphorus content and P uptake by grains

The P content in grains varied from 0.375 to 0.486 per cent (mean of 0.440%) and 0.408 to 0.515 per cent (mean of 0.467%) during first and second year, respectively (Table 3). Highest P content of 0.486 and 0.515 per cent was recorded with the application of 80 and 120 kg N ha^{-1} in combination with BGA inoculation during kharif 2000 and 2001, respectively. In line with the P content and yield, highest P uptake (26.49 and 26.47 kg ha^{-1}) was recorded during both the years with the application of 80 and 120 kg N ha^{-1} along with BGA application. Increased levels of N application either alone or in combination with biofertilizer (BGA) showed positive and significant effect of P content as well as P uptake by grain, which might be due to synergistic relation between N and P. Significant effect of BGA inoculation with all the levels of fertilizer N on P content and its uptake was observed in both the crops. Positive effect of BGA on P uptake by rice has also been reported by Dixit and Gupta (2000).

Potassium content and K uptake by grains

The mean K content in the grains was found to be 0.390 and 0.404 per cent in the first and second crop of rice (Table 3). Increased levels of N application either separately or in combination with BGA showed a significant increase of K content by grains. Highest K content in grain (0.418 and 0.434%) was observed with the combined application of 80 and 120 kg N ha^{-1} along with BGA inoculation during the first and second year. The K content was

Table 3. Effect of different levels of N in combination with BGA on nutrient composition and uptake by grains

Treatment	2000			2001		
	N	P	K	N	P	K
			Nutrient composition (%)			
1. Control	0.740	0.375	0.356	0.773	0.408	0.362
2. 40 kg N ha^{-1}	0.780	0.440	0.383	0.873	0.455	0.393
3. 80 kg N ha^{-1}	1.040	0.443	0.390	1.060	0.479	0.411
4. 120 kg N ha^{-1}	1.140	0.480	0.415	1.187	0.499	0.429
5. Blue green glade	0.753	0.395	0.362	0.780	0.415	0.374
6. 40 kg N ha^{-1} + BGA	1.020	0.465	0.404	1.100	0.474	0.404
7. 80 kg N ha^{-1} + BGA	1.200	0.486	0.418	1.160	0.493	0.424
8. 120 kg N ha^{-1}	-	-	-	1.193	0.515	0.434
Mean	0.953	0.440	0.390	1.016	0.467	0.404
SEd	0.0305	0.0054	0.0052	0.0221	0.0049	0.0035
C.D. at 5%	0.0544	0.0096	0.0093	0.0388	0.0087	0.0062
			Nutrient composition (kg ha^{-1})			
1. Control	30.53	14.08	13.39	30.64	16.18	14.35
2. 40 kg N ha^{-1}	36.23	20.45	17.78	37.19	19.36	16.72
3. 80 kg N ha^{-1}	52.88	22.38	19.76	48.66	21.94	18.85
4. 120 kg N ha^{-1}	60.74	25.41	22.03	56.78	23.86	20.50
5. Blue green glade	33.05	17.29	15.80	31.33	16.67	15.02
6. 40 kg N ha^{-1} + BGA	52.67	23.97	20.81	52.80	22.78	19.43
7. 80 kg N ha^{-1} + BGA	65.38	26.49	22.80	59.19	25.16	21.65
8. 120 kg N ha^{-1}	-	-	-	61.33	26.47	22.33
Mean	47.36	21.44	18.91	47.15	21.50	18.56
SEd	5.245	1.723	1.562	1.425	0.541	0.514
C.D. at 5%	9.346	3.070	2.784	2.509	0.953	0.906

significantly increased with the combined application of different levels of N up to 80 kg N ha^{-1} and BGA in comparison to their respective doses of fertilizer N alone, while the higher doses of N application and BGA showed non significant increase in K content by grains. Alike the K content, highest uptake of K by grain (22.80 and 22.33 kg ha^{-1}) was recorded by the combined application of BGA and 80 and 120 kg N ha^{-1} during the first and second year, respectively. The uptake of K by grains significantly increased with the combined application of BGA and different levels of N as compared to application of fertilizer N alone during both the seasons. Significant effect on K uptake was observed due to NPK fertilization and BGA inoculation, similar to the findings of Mishra and Sharma (1997) and Dixit and Gupta (2000).

Effect of integrated use of nitrogen and BGA on yield and uptake response and N recovery

The per cent yield response in terms of grain yield increased positively up to application of 120 kg N ha^{-1}. The uptake response in respect of N was ranged from 2.25 to 114.15 per cent (Table 4). Highest yield response (59.61 and 29.72%) and N uptake (114.15 and 100.16%) was recorded with the application of highest level of N in combination with biofertilizer during the first and second year, respectively. Higher doses of N application along with BGA inoculation showed lesser crop response in terms of grain yield and nutrient uptake. Inoculation of N fixing biofertilizer without addition of chemical fertilizer N showed a yield response to an extent of 28% during the first year and a low response (1.34%) during the second year. An increase of 36, 9 and 5 per cent during the first year and 7, 8 and 4 per cent grain yield during the second year with the increased doses of N application from 0 to 40, 40 to 80 and 80 to 120 kg ha^{-1}, respectively. However, the uptake response in respect of N for the same doses of N application was increased to an extent of 19, 46 and 15 per cent during the first season and 21, 31 and 17 per cent during the second season. It was evident from the results that the crop showed higher response to lower N application and lesser response to higher fertilizer doses. Highest N recovery from the applied fertilizer N (55.35 and 55.40%) was recorded with the combined application of 40 kg N ha^{-1} and BGA followed by 80 kg N ha^{-1} + BGA. Among the graded doses of N application, highest N recovery was found to be with 80 kg N ha^{-1} closely followed by 120 kg N ha^{-1}. It was noticed that the efficiency of applied N was significantly improved with the inoculation of N fixing biofertilizer (BGA) as compared to application of fertilizer N alone, which showing the fertilizer economy of 30-40 kg N ha^{-1}. Venkataraman (1977) also concluded that one-third of the recommended dose of fertilizer N could be conserved without affecting crop productivity through the inoculation of BGA under extensive field trials as conducted in different locations of India.

Effect of different levels of N and BGA on soil properties

It was observed that soil pH varied from 5.5 to 5.9 with the application of different levels of N and in combination with biofertilizer (Table 5). Inoculation of BGA either alone or in combination with chemical fertilizer N caused a marginal increase of soil pH and salt concentration. Organic carbon content of the treatments varied from 0.48 to 0.76% as against the initial value of 0.62%. Application of 120 kg N ha^{-1} in combination with BGA has recorded highest organic carbon content of 0.76%. The increase of organic carbon with the inoculation of algae, being a photosynthetic organism, could add organic materials to the soil, similar to the findings of Singh (1961). There was a marginal increase in available nitrogen status due to application of graded doses of N either alone or in combination with BGA. Sannigrahi and Mandal (1977) have also reported similar positive effect of BGA on total N content of the soil. It was found that a slight increase in available P status from the initial value of 8.26 to 8.76 kg ha^{-1} with highest value in the treatment of 120 kg N ha^{-1} + BGA. Similar trend was observed in available K status with the application of different levels of N and in combination with BGA. Increase in available K content after harvest of the crops might be due to biodegradation of root biomass left in the soil. These results

Table 4. Effect of different levels of N in combination with BGA on yield and uptake response and N recovery

Treatment	2000			2001		
	Per cent yield response	Per cent N uptake response	Apparent N recovery (%)	Per cent yield response	Per cent N uptake response	Apparent N recovery (%)
40 kg N ha^{-1}	35.69	18.67	14.25	7.42	21.37	16.38
80 kg N ha^{-1}	47.86	73.21	27.94	15.64	58.81	22.53
120 kg N ha^{-1}	54.95	98.95	25.18	20.69	85.31	21.78
Blue green glade	27.52	8.25	-	1.34	2.25	-
40 kg N ha^{-1} + BGA	50.48	72.52	55.35	21.19	72.32	55.40
80 kg N ha^{-1} + BGA	59.61	114.15	43.56	28.81	93.18	35.69
120 kg N ha^{-1}	-	-	-	29.72	100.16	25.58

Table 5. Effect of different levels of N in combination with BGA on soil properties

Treatment	pH	EC (dS m^{-1})	Org. C (%)	Available nutrient (kg ha^{-1}) N	P	K
Initial	5.5	1.24	0.62	272	8.26	134.42
Control	5.5	1.18	0.48	246	7.86	129.56
40 kg N ha^{-1}	5.7	1.32	0.66	280	8.31	140.25
80 kg N ha^{-1}	5.8	1.45	0.72	290	8.38	152.38
120 kg N ha^{-1}	5.7	1.43	0.71	296	8.40	158.40
Blue green glade	5.6	1.34	0.65	278	8.28	140.52
40 kg N ha^{-1} + BGA	5.6	1.48	0.68	284	8.36	148.73
80 kg N ha^{-1} + BGA	5.9	1.60	0.74	294	8.62	165.91
120 kg N ha^{-1}	5.9	1.53	0.76	302	8.76	168.70

are in accordance with the findings of Dixit and Gupta (2000).

In conclusion, integrated application of 80 kg N ha^{-1} and inoculation of N fixing biofertilizer (BGA) is most economical to obtain highest and sustainable crop yields and to minimize the expenditure on fertilizer cost to an extent of 30-40 kg N ha^{-1} as well as to improve the fertility status of soil.

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EFFECT OF LEVELS AND MODE OF PHOSPHORUS APPLICATION WITH AND WITHOUT BIOFERTILIZERS ON YIELD AND NUTRIENT UPTAKE BY CHICKPEA (*CICER ARIETINUM*)

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ABSTRACT

A experiment was conducted to study the effect of levels and mode of phosphorus application with and without phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) on yield and nutrient uptake by chickpea. Inoculation of biofertilizers increased yield and nutrient uptake. The inoculation of PSB+VAM recorded higher yield and nutrient uptake over PSB and VAM separately. The yield and nutrient uptake also increased with increasing doses of phosphorus. Aqua placement of phosphorus also improved yield and nutrient uptake by chickpea.

Key words : PSB, VAM, phosphorus, nitrogen, potassium, aqua and dry placement of phosphorus, chickpea, dryland.

Pulses form an integral part of the vegetarian diet and the cheapest source of protein for the poor farmers of the Indian sub-continent. Among pulses, chickpea (*Cicer arietinum*) is one of the most important pulse crops of India. Leguminous plants have a high requirement of phosphorus and its deficiency is probably the major limitation for productivity (Saraf, 1983) because approximately 95-99% of soil phosphorus is not directly available to plant roots (Bieleski, 1973). There is a need to develop a suitable agricultural system which requires lower fertilizers input with higher fertilizer use efficiency. The identification of micro-organisms capable of solubilizing and mobilizing the native and applied phosphorus has opened new vistas for phosphorus nutritions. The microbial inoculation with PSB not only increase the availability of native fixed phosphorus but also augment the efficiency of applied superphosphate by reducing phosphate fixation in soil (Gaind and Gaur, 1991). Today, VAM fungi is the most widespread type of symbiotic association with roots and make a significant contribution to crop plants and nutritions, especially phosphorus (Smith and Read, 1997). In drought situation where water is confined to small pores, mycorrhizal hyphae might be better able to contribute to plant water demand and to provide higher resistance to drought situation where water is confined to small pores, mycorrhizal hyphae might be better able to contribute to plant water demand and to provide higher resistance to drought (Ruiz-Lozano et al., 1995). The objective of present study was to investigate the influence of levels and mode of phosphorus application in presence and absence of biofertilizers on yield and nutrient uptake.

MATERIALS AND METHODS

A field experiment was conducted during the rabi seasons of 2000-2001 and 2001-2002 at Indian Agricultural Research Institute, New Delhi. The experiment was laid out in balanced confounded asymmetrical factorial design with three replications in which four levels of biofertilizers inoculation (no inoculation, phosphate solubilizing bacteria (PSB), vesicular arbuscular mycorrhiza (VAM) and PSB + VAM), three levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) and two mode of phosphorus application (dry placement and aqua placement) with 20,000 liters of water/ha). There were two blocks per replication and 12 plots per block.

The soil was alluvial sandy loam with slightly alkaline in reaction (7.4) low in organic carbon (0.42), available nitrogen (251.72 kg N/ha), phosphorus (9.11 kg P/ha) and medium in available potassium (269.58 kg K_2O). Seeds of chickpea (BG 256) were treated with PSB cultures prior to sowing and dried under shade. Seeds were sown in rows with proper seed rate and spacing. A total of three VAM spores/plant were placed. The pure VAM culture was mixed thoroughly with sand and placed in the furrow below the seed. Five tagged plants were taken from each treatment and yield attributes and yield were recorded from them. The data recorded on yield attributes and yield were analysed using the Statistical Analysis System (SAS) General Linear Model Procedure (GLM PROC).

RESULTS AND DISCUSSION

Yield

Inoculation of biofertilizers showed significant effect on grain yield in both the years as well as pooled data (Table 1). In first year, PSB + VAM inoculation recorded significantly higher grain yield as compared to PSB or VAM inoculation, whereas in second year, PSB+VAM inoculation recorded higher grain yield over PSB inoculation. In pooled data PSB+VAM inoculation recorded higher grain yield as compared to PSB or VAM inoculation. The higher grain yield due to PSB and VAM might be due to better growth and yield attributes. The PSB is known to produce vitamins (Baya et al., 1981) and indole acetic acid and gibberellins like substances (Sattar and Gaur, 1987). These growth factors in combination with better nutritional condition due to increase in availability of phosphorus in soil might have played role in increasing the grain yield of chickpea. On the other hand, VAM helped in supply of essential nutrients and water to plants resulted in better yield attributed that led to increase in grain yield. The dual inoculation recorded higher grain yield might be due to synergistic effect between PSB and VAM. The increase in grain yield by PSB and VAM also reported by Mukherjee and Rai (2000). Inoculation of biofertilizers had no significant effect on husk yield and harvest index. Stalk yield was significant in second year only. Phosphorus application increased grain yield up to 60 kg P_2O_5/ha. This difference between 0 and 30 kg P_2O_5/ha was significant in both the years as well as on pooled data. Whereas the increments between 30 and 60 kg P_2O_5/ha was statistically significant in first year

Table 1. Grain, husk and stalk yield and harvest index as influenced by biofertilizer inoculation, levels and mode of phosphorus application

Traetments	Grain yield (q/ha)			Husk yield (q/ha)		Stalk yield (q/ha)		Harvest index (%)	
	2000-01	2001-02	Pooled	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Biofertilizers									
No inoculation	23.16	18.05	20.60	6.67	5.16	29.59	19.92	39.05	41.87
PSB	24.94	19.71	22.33	7.11	4.41	31.46	22.64	39.71	41.87
VAM	25.66	20.39	23.03	7.10	5.10	31.00	22.09	40.24	42.75
PSB+VAM	27.28	20.89	24.08	7.10	5.27	31.95	22.73	40.75	42.87
SEm(±)	0.40	0.39	0.26	1.04	0.36	1.34	0.56	1.03	0.63
C.D. (0.05)	1.14	1.12	.76	NS	NS	NS	1.59	NS	NS
P levels (kg P_2O_5/ha)									
0	23.61	18.63	21.12	6.17	4.88	29.79	20.63	39.67	42.19
30	25.78	20.21	23.00	7.07	5.04	31.40	21.82	40.37	42.90
60	26.35	20.43	23.41	7.74	5.03	31.870	23.08	40.44	41.13
SEm(±)	0.34	0.34	0.23	0.90	0.30	1.16	0.48	0.89	0.55
C.D. (0.05)	0.98	0.97	0.66	NS	NS	NS	1.37	NS	NS
Mode of P application									
Dry placement	24.52	19.38	21.95	6.36	5.03	30.95	21.16	39.77	42.51
Aqua placement	26.00	20.14	23.07	7.63	4.94	31.05	22.52	40.55	42.31
SEm(±)	0.28	0.27	0.19	0.73	0.25	0.95	0.39	0.73	0.45
C.D. (0.05)	0.80	NS	0.54	NS	NS	NS	1.12	NS	NS

and pooled data. The percentage increase with 30 and 60 kg P_2O_5/ha over no phosphorus application was 9.19 and 11.60 in first year, 8.48 and 9.66 in second year and 8.9 and 10.8 in pooled data, respectively. This improvement in yield with increased supply of phosphorus might be due to profuse nodulation leading to increase in nitrogen fixation which in turn had positive effect on photosynthetic organ resulted higher grain yield. Saraf et al. (1997) also noted such increase in grain yield with increasing levels of phosphorus. Phosphorus application had no significant effect on husk yield and harvest index. Stalk yield was significantly increased with increasing levels of phosphorus in first years only. Between mode of application, aqua placement of phosphorus significantly increased the grain yield in first year and pooled data. The percentage increase by aqua placement over dry placement was 6.03, 3.92 and 5.10 in first year, second year and pooled data, respectively. Mode of phosphorus application had no effect on husk yield and harvest index. In second year, aqua placement significantly increased the stalk yield.

No significant interaction between biofertilizers and phosphorus on the grain yield were noted.

The environmental conditions prevailed in the two years during the period of crop growth were not identical in terms of precipitation and temperature. In first year, precipitation was 41.14 mm during entire growth period but during the second year only 26.61 mm. In second year, temperature rise was high at grain filling stage as compared to first year.

Nutrient uptake

Nitrogen

Inoculation of biofertilizers significantly increased the nitrogen uptake by grain in both the years whereas nitrogen uptake by husk and stalk in second year only (Table 2).

Nitrogen uptake was significantly higher with PSB+VAM inoculation over PSB and VAM alone by grain in first year. In general, PSB + VAM inoculation was superior over PSB or VAM alone regarding nitrogen uptake. The above findings, in general, reveal that nitrogen uptake by grain, husk and stalk increased might be due to increased nodulation and yield as well as nitrogen content resulting in higher nitrogen yield.

Nitrogen uptake by grain and stalk significantly increased with increasing levels of phosphorus in both the years whereas nitrogen uptake by husk was non significant. Singh and Prasad (1976) also reported increase in nitrogen uptake with increasing dose of phosphorus. Mode of phosphorus application had a significant influence on nitrogen uptake by grain whereas nitrogen uptake by husk and stalk was non significant.

Phosphorus

Biofertilizer inoculation significantly increased the phosphorus uptake by grain and stalk whereas by husk was non-significant (Table 3). The dual inoculation of PSB+VAM was superior regarding nitrogen uptake as compared to PSB or VAM alone. The increased phosphorus uptake by grain and stalk might be due to synergistic effect between PSB and VAM.

Table 2. N uptake by grain, husk, stalk and total uptake as influenced by biofertilizers, levels and mode of phosphorus application

Traetments	Grain		Husk		Stalk		Total	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Biofertilizers								
No inoculation	91.56	70.53	10.07	4.05	36.23	11.92	137.86	86.50
PSB	99.97	78.43	10.80	4.60	39.56	15.65	150.33	98.67
VAM	103.76	81.24	11.01	4.93	39.58	15.87	154.35	102.04
PSB+VAM	112.23	83.52	11.22	5.28	40.80	16.40	164.25	105.20
SEm(±)	2.20	1.92	1.84	0.38	1.84	0.76	3.88	2.39
C.D. (0.05)	6.25	5.46	NS	1.09	NS	2.16	11.02	6.80
P levels (kg P_2O_5/ha)								
0	92.52	72.48	9.21	4.18	36.03	13.23	137.77	89.90
30	103.17	80.93	10.38	4.84	39.14	14.91	152.70	100.69
60	109.95	81.88	12.91	5.12	41.95	16.74	164.82	103.75
SEm(±)	1.90	1.66	1.59	0.33	1.60	0.66	3.36	2.07
C.D. (0.05)	5.41	4.73	NS	NS	4.54	1.87	9.54	5.88
Mode of P application								
Dry placement	98.90	76.18	9.72	4.69	38.50	14.30	147.13	95.18
Aqua placement	104.86	80.68	11.95	4.74	39.58	15.62	156.93	101.05
SEm(±)	1.55	1.36	1.30	0.27	1.30	0.54	2.74	1.69
C.D. (0.05)	4.42	3.86	NS	NS	NS	NS	7.79	4.80

Table 3. P uptake by grain, husk, stalk and total uptake as influenced by biofertilizers, levels and mode of phosphorus application

Traetments	Grain		Husk		Stalk		Total	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Biofertilizers								
No inoculation	7.82	4.18	0.26	0.17	0.76	0.37	8.84	4.75
PSB	8.54	4.91	0.28	0.18	0.85	0.45	9.68	5.35
VAM	8.83	5.14	0.29	0.19	0.86	0.47	9.98	5.81
PSB+VAM	9.41	5.49	0.43	0.21	1.24	0.49	11.08	6.21
SEm(±)	0.24	0.16	0.11	0.02	0.11	0.03	0.33	0.17
C.D. (0.05)	0.68	0.47	NS	NS	0.33	0.08	0.93	0.48
P levels (kg P_2O_5/ha)								
0	7.73	4.03	0.21	0.17	0.81	0.41	8.77	4.62
30	8.79	4.93	0.40	0.20	0.86	0.43	10.06	5.56
60	9.43	5.83	0.39	0.21	1.10	0.50	10.91	6.54
SEm(±)	0.21	0.14	0.10	0.01	0.10	0.02	0.28	0.14
C.D. (0.05)	0.59	0.41	NS	NS	NS	0.07	0.80	0.41
Mode of P application								
Dry placement	8.34	4.63	0.26	0.19	0.95	0.42	9.56	5.24
Aqua placement	8.96	5.24	0.41	0.19	0.89	0.47	10.27	5.90
SEm(±)	0.17	0.11	0.08	0.01	0.08	0.02	0.23	0.12
C.D. (0.05)	0.48	0.33	NS	NS	NS	NS	0.66	0.34

Table 4. P uptake by grain, husk, stalk and total uptake as influenced by biofertilizers, levels and mode of phosphorus application at harvest

Traetments	Grain		Husk		Stalk		Total	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Biofertilizers								
No inoculation	33.84	21.85	9.01	5.95	47.67	25.29	90.52	53.09
PSB	37.29	23.83	9.60	6.95	54.43	29.47	101.32	60.25
VAM	41.42	24.92	9.80	6.98	55.11	30.25	106.33	62.14
PSB+VAM	45.43	25.95	9.88	7.27	56.81	21.35	112.13	64.58
SEm(±)	1.13	0.48	1.47	0.51	2.63	1.10	3.52	1.26
C.D. (0.05)	3.21	1.38	NS	NS	7.47	3.13	10.01	3.58
P levels (kg P_2O_5/ha)								
0	34.08	22.34	8.33	6.53	51.47	26.40	93.88	55.28
30	39.93	24.84	9.54	6.84	54.00	29.64	103.59	61.32
60	44.47	25.23	10.84	7.00	55.04	31.23	110.35	63.47
SEm(±)	0.98	0.42	1.27	0.44	2.28	0.95	3.05	1.09
C.D. (0.05)	2.78	1.19	NS	NS	NS	2.71	8.66	3.10
Mode of P application								
Dry placement	37.88	23.58	8.63	6.77	53.76	27.64	100.27	58.01
Aqua placement	41.11	24.69	10.58	6.81	53.25	30.54	104.95	62.05
SEm(±)	0.80	0.34	1.04	0.36	1.86	0.78	2.49	0.89
C.D. (0.05)	2.27	0.97	NS	NS	NS	2.21	NS	2.53

It is well known that PSB have ability to solubilize native as well as applied phosphorus. On the other hand, the external hyphae of VAM constitutes an important pathway for phosphate transport through soil as they extend beyond the phosphorus depletion zone surrounding the absorbing root and providing access to phosphorus which otherwise transport only by slow diffusion process (Clarkson, 1985). Phosphorus in both the years whereas uptake by stalk was significant in second year only. Application of 60 kg P_2O_5/ha recorded significantly higher phosphorus uptake by grain in both the years and by stalk in second year. This increase in phosphorus uptake might be due to increased biomass production and partly due to increase in its concentration. These findings are corroborate with the findings of Dev et al. (1987). Aqua placement of phosphorus significantly increased in phosphorus uptake in grain whereas uptake by husk and stalk were insignificant.

Potassium

Inoculation of biofertilizers significantly influenced the potassium uptake by grain and stalk whereas uptake by husk was non-significant (Table 4). The dual inoculation of PSB + VAM was better regarding potassium uptake than PSB or VAM alone. Potassium uptake by grain also significantly influenced by levels and mode of phosphorus application.

The above results indicate that nitrogen, phosphorus and potassium uptake were higher in first year than second year. This could be due to higher biomass production under favourable weather conditions especially precipitation in first year.

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ECONOMICS OF PRODUCTION AND MARKETING OF VEGETABLES IN ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

A study was undertaken to find out the economics of production and marketing of vegetables in Andaman and Nicobar Islands. Results indicated that the yield of ginger, cucumber, bitter gourd, chilli and ridge gourd were higher in that order. Correspondingly, the total cost of cultivation was observed to be higher for ginger, bitter gourd, chilli, brinjal, bhendi etc. It was also found that the yield of all the vegetables were higher in hilly land than in valley land. Cost-benefit ratio was the higher for chilli followed by cucumber, bhendi, marsa, cowpea, snakegourd etc. and it was found to be higher in hilly land than in valley land for all the vegetables. The margin to both the wholesaler and the retailer was highest in ginger (Rs. 14.10 and Rs. 32.50 per kg, respectively). Conversely, the marketing margin was the lowest in basal and marsa (Rs. 0.90) for wholesaler and in potato (Rs. 1.50) for retailer.

Key words : Marketing, margin, vegetables, Andaman, Island.

Vegetable cultivation in the Andaman and Nicobar islands is done only on limited scale. The productivity of vegetables per unit area is also very low (Gajja, 1988). The total requirement of potato and onion is met from the mainland and often vegetables like tomato, cauliflower, cabbage and carrot are also imported from the mainland more than 1200 km away. But the vegetables like cowpea, bhendi, bottle gourd, snake gourd, cucumber, chillies, water melon etc. are grown in different islands and find their way to Port Blair in South Andaman, which is the main consumption centre. Here, the vegetable cultivation is done mainly on subsistence basis because of the following reasons : (a) There is no regulated market for marketing of vegetables in the islands, (b) There is high pressure of insect-pests and disease in the islands and their effective control increases the cost of production and (c) The maximum area under vegetables can come during dry season but the problem of stray cattle, absence of suitable farm power and machinery to prepare a good seed bed and to conserve moisture and absence of irrigation facilities discourage the farmers in increasing the area under vegetables (Singh, 1987). It is still in primitive stage and hence not done on commercial basis. Moreover, the farmers have to confrong with many natural disturbances such as heavy rain, water logging during rainy season and water scarcity during summer season apart from severe exploitation from middlemen in vegetable trade. Yield of different vegetables are highly variable in manure in these islands. Because of their high perishability, farmers cannot keep it for long in order to fetch a remunerative price. Moreover, marketing process handled by ANIDCO has not been effective since it functions as per the schedule office timings. Hence, a number of middlemen has formed an unregulated market in Port Blair.

Keeping all these in view, a study was undertaken to find out the economics and marketing of vegetable cultivation in Andaman and Nicobar islands so as to estimate the cost of production of different vegetables, returns, cost-benefit ratio and marketing margins of different middlemen involved in vegetable trade in the islands.

MATERIALS AND METHODS

Commensurate with the objectives of the study, two villages viz., Maccapahar and Calicut from the South Andaman island of Andaman district were purposively selected. Simple random sampling was used to select the island farmers who grow vegetables in their backyard. Information on various aspects of vegetable cultivation such as area under vegetables, nature of their land whether hilly or valley, yield, cost of cultivation, gross return, net return, price at farm gate etc. for different vegetables grown by them in the study area were collected from 50 sample farmers. Similarly, data on marketing cost, which comprises mostly transport cost and prices at wholesaler's level and retailer's level were also collected from these two middlemen. Using all these available information, cost-benefit ratio was calculated for all the vegetables grown in both hilly land and valley land in the study area. similarly, marketing margin of middlemen involved in vegetable trade in the islands was also calculated.

RESULTS AND DISCUSSION

Cost of cultivation and returns from different vegetables grown in the study area are given in Table 1. It could be observed from the table that the yield of ginger, cucumber, bittergourd, chilli and ridgegourd were higher in that order followed by brinjal, bhendi, pumpkin, cowpea etc. Correspondingly, the total cost of cultivation was observed to be higher for ginger, bitter gourd, chilli, brinjal, bhendi etc. From this, it could be known that cucumber and brinjal were produced efficiently. It was also found that the yield of all vegetables were higher in hilly land than in valley land. This might be due to the problem of water logging during rainy season in the valley land. But there is no such difference between hilly and valley lands as far as the cost of cultivation is concerned.

Similarly, it could be seen from the table that both gross return and net return were higher in case of chilli, ginger, bitter gourd, cucumber and bottlegourd. Here also, these parameters were higher in hilly land when compared to valley land. Accordingly, cost-benefit ratio were estimated for all the vegetables grown in the study area and it was found to be highest for chilli (1 : 12.7 in hilly land and 1 : 3.4 in valley land) followed by cucumber, bhendi, marsa, cowpea, snakegourd etc. In consonance with the findings of higher yield in hilly land, cost-benefit ratio ws also higher for hilly

Table 1. Yield and economics of vegetable cultivation in Andaman and Nicobar Islands

Vegetables	Yield (q/ha)		Cost of cultivation (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		Cost-benefit ratio	
	Hilly land	Valley land	Hilly land	Valley land	Hilly land	Valley land	Hilly land	Valley land	Hilly land	Valley land
Cowpea	81.4	39.0	35255	37132	97633	46800	62379	9668	1 : 2.7	1 : 1.2
Bhendi	88.9	30.0	36335	24135	106633	36000	70298	11865	1 : 2.7	1 : 1.5
Bottlegourd	78.7	60.0	18103	18915	21500	24000	133397	5085	1 : 1.7	1 : 1.3
Pumpkin	83.4	37.5	25119	20755	50060	22500	16387	1745	1 : 2.2	1 : 1.1
Cucumber	143.7	37.5	23976	30750	143750	37500	119775	6750	1 : 6.7	1 : 1.2
Bittergourd	133.7	22.5	68949	33876	160500	135000	183102	37900	1 : 2.2	1 : 1.0
Radish	46.7	-	23649	-	32725	-	9077	-	1 : 1.4	-
Chilli	113.2	39.0	58113	34475	711875	117000	631915	82525	1 : 12.7	1 : 3.4
Basal	45.2	-	27838	-	36160	-	9078	-	1 : 1.4	-
Ginger	157.5	-	240015	-	630000	-	389985	-	1 : 2.5	-
Marsa	68.8	-	17317	-	50000	-	32684	-	1 : 2.9	-
Kattabhaji	61.3	-	10661	-	24500	-	13839	-	1 : 2.2	-
Ridgegourd	112.5	30.0	30750	32400	56250	3000	25500	-2400	1 : 1.8	1 : 1.0
Brinjal	100.0	-	38000	-	100000	-	62000	-	1 : 2.6	-
Snakegourd	125.0	-	27420	-	75000	-	47580	-	1 : 2.7	-
Maize	9.0	-	17691	-	7200	-	-10491	-	1 : 0.4	-
Water melon	-	75.0	-	9225	-	18750	-	9525	1 : 2.0	-

land than for valley land for all the vegetables.

The prices of different vegetables at different levels of marketing are listed in Table 2. It could be observed from the table that the price at the wholesale market was the highest for chilli (Rs. 53.30), followed by ginger (Rs. 52.50) and carrot (Rs. 45.00), which is transported from mainland. Similarly, the price at the wholesale market was found to be the lowest in case of nalli bhaji, katta bhaji both (Rs. 4.00), followed by basal and marsa both (Rs. 6.00) and potato and radish both (Rs. 8.00). The price at the retail market was found to be the lowest for katta bhaji (Rs. 6.00), followed by basal, marsa and nalli bhaji (all Rs. 8.00) and potato (Rs. 9.50).

The marketing cost and margins to the middlemen per kg of vegetables are given in Table 3. It is seen that the margin to the wholesaler is the highest in ginger (Rs. 14.10), followed by ridge gourd (Rs. 9.10) and tomato (Rs. 8.40). Similarly, the margin to the retailer is the highest in ginger (Rs. 32.50), followed by pumpkin (Rs. 10.00) and cabbage (Rs. 6.25). Conversely, the marketing margin to the wholesaler is the lowest in basal and marsa both (Rs. 0.90),

Table 2. Price of vegetables at different levels in the bay Islands

Vegetables	Price at farmgate (Rs./kg)	Price at wholesaler's market	Price at retailer's market
Brinjal	7.50	10.50	14.40
Tomato	10.60	22.00	26.60
Cabbage	5.00	15.75	22.00
Chilli	40.00	53.30	73.30
Ginger	37.50	52.50	85.00
Potato	3.00	8.00	9.50
Beans	16.00	45.00	50.00
Basal	5.00	6.00	8.00
Marsa	5.00	6.00	8.00
Bhendi	20.00	25.60	30.00
Cowpea	12.00	18.00	22.00
Bottlegourd	10.00	12.00	16.00
Coccinia	8.00	15.60	20.00
Banana	5.00	7.60	10.60
Nalli bhaji	2.00	4.00	8.00
Katta bhaji	1.50	4.00	6.00
Ridgegourd	10.00	20.00	24.00
White pumpkin	6.00	10.00	16.00
Radish	5.00	8.00	10.00
Pointedgourd	10.00	15.00	20.00
Snakegourd	5.00	10.00	16.00
Carrot	16.00	45.00	50.00
Pumpkin	6.00	10.00	20.00
Cucumber	10.00	15.00	20.00
Bittergourd	15.00	22.00	28.00

followed by bottle gourd (Rs. 1.10) and banana (Rs. 1.70). And retailer's margin is found to be the lowest in potato (Rs. 1.50), followed by basal, marsa, katta bhaji and radish (all Rs. 2.00). The main reason for the high marketing margin of certain vegetables to the middlemen might be due to the fact that they are transported from main land for consumption at these islands. Similarly, the existenec of low marketing margin for certain other vegetables to the middlemen is because they are cultivated mostly in these bay islands itself. It is interesting to note that marketing cost for all the vegetables were found to be lower when compared to their marketing margin to the middlemen, except for carrot, potato and beans, which mainly come from main land and hence their transport cost add to the marketing cost in a significant manner.

The study shows that hilly land is suitable for vegetable cultivation in a profitable manner in bay islands, because there is more yield and income generation in hilly land than in valley land. Moreover, by educating the farmers regarding the management of water logging and pest

Table 3. Marketing costs and margins of middlemen for vegetables at different levels in the bay Islands

Vegetables	Marketing cost (Rs./kg)	Marketing margin (Rs./kg) Wholesaler	Retailer
Brinjal	0.90	2.10	3.90
Tomato	3.00	8.40	4.60
Cabbage	5.00	5.75	6.25
Chilli	0.90	2.40	20.00
Ginger	0.90	14.10	32.50
Potato	2.80	2.20	1.50
Beans	23.00	6.00	5.00
Basal	0.10	0.90	2.00
Marsa	0.10	0.90	2.00
Bhendi	0.90	4.70	4.40
Cow pea	0.90	5.10	4.00
Bottle gourd	0.90	1.10	4.00
Coccinia	2.00	5.60	4.40
Banana	0.90	1.70	3.00
Nalli bhaji	0.10	1.90	4.00
Katta bhaji	0.10	2.40	2.00
Ridge gourd	0.90	9.10	4.00
White pumpkin	2.00	2.00	6.00
Radish	0.10	2.90	2.00
Pointed gourd	2.00	3.00	5.00
Snake gourd	2.00	3.00	6.00
Carrot	23.00	6.00	5.00
Pumpkin	0.90	3.10	10.00
Cucumber	0.90	4.10	5.00
Bitter gourd	0.90	6.10	6.00

control, the yield in valley land could be improved. The study also shows that the margin to middlemen are very high. The retail price of different vegetables could be reduced by providing storage facitities during the transaction period, subsidizing the transport cost and increasing the frequency of shipping service from main land and other surrounding islands. These steps will not only increase supplies to the market but also reduce the margin to the middlemen. Apart from these, the Government Consumer Cooperative Society should also enter into the vegetable market in an effective manner so as to enable the producers to get a remunerative price as well as consumers to pay a reasonable price for the vegetables in Andaman and Nicobar islands.

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GENETIC STUDY AND PATH ANALYSIS IN PEARL MILLET

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ABSTRACT

The correlation and path co-efficient analysis were worked out in twenty-one parents and hundred and ten F_1 genotypes in pearlmillet for ten characters. The grain yield had high significant positive correlation with plant height (0.652), earhead length, earhead girth and productive tillers. The leaf width showed very high positive association with earhead length, earhead girth, and 100-grain weight and with grain yield too. The path coefficient study revealed that the earhead length had high positive direct effect on grain yield followed by plant height, earhead girth and productive tillers. The 100-grain weight showed high indirect effect through number of leaves, plant height and leaf length and the number of leaves exhibited high indirect effect on leaf length and earhead length on grain yield.

Key words : Pearlmillet, correlation, path analysis.

The inherent association between two variables might be either due to pleiotropic action of genes or due to linkage or more likely both (Falconer, 1989). This association and direction of relationship between variables were statistically elaborated by correlation coefficients. This correlation study provided better understanding of yield components, which helps the breeder during selection (Robinson *et al.* 1951). The path-coefficient analysis provides an effective means of finding out direct and indirect causes of association and it measures the direct and indirect contribution of various independent characters on a dependent character in general yield. It also estimates the residual effect present in this study. Keeping above points in view, the present investigation was made to identify all important yield variables related with the grain yield.

MATERIALS AND METHODS

An experiment consisting of hundred and ten hybrids and twenty one parents including 11 lines (L111A, 81A, 842A, ICMA91777, ICMA92555, L66A, 303A, Tri23A, 81Av, 732A and ICMA90111) and ten testers (ICP662, ICP829, IPC665, IPC803, IPC816, IPC1054, IPC1264, ICMP423, MC91C1 and MC94Co) was conducted in a randomized replicated trial with two replications during *kharif,* 1999. Each treatment had five rows of four-meter length spaced at 45 cm distance and seeds were sown at 15 cm apart in each row. Observations were recorded on randomly selected five plants from each treatment for ten biometrical characters viz., the days to 50% flowering, the plant height, the productive tillers, the number of leaves, the leaf length, the leaf width, the earhead length, the earhead girth, the 100-grain weight and the grain yield. The correlation coefficients were calculated according to Johnson *et al.* (1955) and path coefficient analysis was worked out as per the method suggested by Wright (1921) and elaborated by Deway & Lu (1959).

RESULTS AND DISCUSSION

The grain yield per plant exhibited strong positive and significant correlation with the plant height, the earhead length, the earhead girth, the productive tillers and the leaf width (Table 1). However, the days to 50% flowering, the number of leaves and the leaf length expressed very meager amount of positive correlation with yield.

Among the yield components, the days to 50% flowering was positively and significantly correlated with the number of leaves, the leaf width and the 100-grain weight. But the plant height had high significant correlation with fodder-related characters and the earhead length. The productive tillers had highly and positively associated with the number of leaves and the earhead girth while negatively correlated with the 100-grain weight and the leaf width. Characters leaf width and leaf length exhibiting highly significant positive correlations with the earhead girth proved that association of photosynthetic (source-sink relationship) area was positively related to yield. The earhead length was found to be significant and negatively associated with the earhead girth. The association of characters said to be genetically linked was high in magnitude with yield in both replications.

Path-coefficient analysis (Table 2)

Table 1. Genotypic correlation co-efficient between different pairs of characters

Characters	Days to 50% flowering	Plant height	Productive tillers	Number of leaves	Leaf length	Leaf width	Earhead length	Earhead girth	100-grain weight	Grain yield
Days to 50% flowering	1.000	0.129	-0.323*	0.620**	0.137	0.549**	0.316*	-0.350*	0.441**	0.221
Plant height		1.000	0.384*	0.394**	0.448**	0536**	0.413**	-0.021	0.289	0.652**
Productive tillers			1.000	0.445**	0.174	-0.141	-0.308*	0.584**	-0.077	0.418**
Number of leaves				1.000	0.025	0.426**	0.563**	-0.824**	0.320*	0.215
Leaf length					1.000	0.458**	0.266	0.640**	0.214	0.111
Leaf width						1.000	0.791**	0.578**	0.314*	0.335**
Earhead length							1.000	-0.421**	-0.083	0.471**
Earhead girth								1.000	0.091	0.425**
100-grain weight									1.000	0.317*

* significant at 5% level** significant at 1% level

revealed that direct effects of the earhead length on seed yield were moderate and positive through their indirect effects on the plant height, the productive tillers, the number of leaves, the leaf length and the earhead girth. The plant height also exhibited moderate effects on the grain yield through positive indirect effects on the days to 50% flowering, the number of leaves and the leaf length and negative indirect effects through the productive tillers, the leaf width, the earhead length, the earhead girth and the 100-grain weight. The recorded residual effect i.e. 0.014 indicated the chosen characters were adequate and good enough for path co-efficient analysis in this study. Moreover the productive tillers were found to exhibit moderate positive effects on the grain yield mostly though indirect effects on the plant height and the leaf length and negative indirect effects on the earhead girth. Considering correlations, direct and indirect effects of yield related characters such as the plant height, the earhead length, the earhead girth and the productive tillers on the grain yield may be given importance for improvement of pearlmillet.

Table 2. Path analysis - Direct (diagonal) and indirect effects

Characters	Days to 50% flowering	Plant height	Productive tillers	Number of leaves	Leaf length	Leaf width	Earhead length	Earhead girth	100-grain weight	Grain yield
Days to 50% flowering	-0.237	0.008	0.062	0.240	0.087	-0.058	0.092	0.068	-0.041	0.221
Plant height	0.428	0.252	-0.074	0.018	0.285	-0.057	-0.040	-0.133	-0.027	0.652**
Productive tillers	0.077	0.264	0.100	0.047	0.110	0.015	-0.089	-0.113	0.007	0.418**
Number of leaves	-0.458	0.269	-0.198	0.045	0.887	-0.729	0.743	0.160	-0.494	0.215**
Leaf length	-0.033	0.012	-0.033	0.257	0.077	-0.102	0.077	-0.124	-0.020	0.111
Leaf width	-0.130	0.123	0.027	0.211	0.109	0.006	0.130	-0.112	-0.029	0.335**
Earhead length	-0.075	0.093	0.100	0.089	0.169	-0.084	0.290	0.081	0.008	0.471**
Earhead girth	0.083	0.083	-0.112	-0.038	0.407	-0.061	-0.122	0.193	-0008	0.425**
100-grain weight	-0.105	0.197	0.015	0.241	0.136	-0.033	-0.024	-0.018	0.093	0.317*

* significant at 5% level ** significant at 1% level Residual effect = 0.014

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EFFECT OF DIFFERENT LEVELS OF POTASSIUM ON FRUIT QUALITY AND YIELD OF SWEET ORANGE

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ABSTRACT

A field experiment was conducted to study the effect of different levels of potassium on fruit quality and yield of sweet orange. Results revealed that different levels of potassium improved the yield and quality of fruit in respect of juice content, total soluble solids and vitamin C while acid content was reduced with the increased level of potassium. Among different levels of potassium, 600g per plant along with fixed dose of N 600g per and P 100g per plant showed maximum yield followed by K 700g per plant. The maximum juice content, total soluble solids and vitamin C content of fruit were obtained by application of K 600g per plant.

Key words : Potassium, yield, fruit quality and sweet orange.

Potassium is an essential element for all living organism. In the plant tissue, the content of K is higher than that of other cation. In fact, potassium is the most important cation in many physiological and biochemical processes. Its magnificient role as quality builder is well established in different crops (Dutta and Dhua, 2000) but scanty information is available on yield and quality of sweet orange grown in red and lateritic tract of Birbhum district. Keeping this in view, the present experiment was undertaken to study the effect of different levels of potassium on yield and fruit quality of sweet orange grown in red and lateritic tract of Birbhum district.

MATERIALS AND METHODS

The present investigation was carried in randomized block design with five replication at the Regional Research sub-station, sekhampur, Bidhan Chandra Krishi Viswavidyalaya on uniformly grown ten years old plants of sweet orange cv. Mossambi. The plants under study were given fixed doses of N and P @ 600g and 100 g per plant per year, respectively, along with variable doses of potassium viz., K0, K100, K200, K300, K400, K500, K600 and K700g/plant/year. The fertilizer was applied in two equal split doses and followed all cultural practices. The matured fruits were harvested and physiocochemical characters were assessed following standard methods as described by tritratable acid content (A-O.A.C., 1984) and ascorbic acid (Ranganna, 1977). The total soluble solids was estimated with the help of hand refractometer. The mean data were analysed statistically and evaluated at 5% level of significance.

RESULTS AND DISCUSSION

In the present investigation application of potassium 100 to 600 g/plant along with fixed dose of N 600g and P 100g/plant/year improved individual fruit weight and yield of tree. Among the different treatments under study K600g/plant/year showed maximum yield (33.50 kg/tree) followed by K700g/plant/year while control recorded only 25.00 kg/tree. Higher levels of potassium also proved more effective as compared to othe rlevels of K in increasing, the individual fruit weight (Table 1). The fruit weight was maximum 176.0g with K 600g/plant/year followed by K500g/plant/ year while minimum 150.0g was recorded from controlled fruit. The highest levels of potassium (K 700g/plant) under study was not so effective over K600g/plant/year. The beneficial effect of K in improving the fruit weight and fruit number was due to more uptake and accumulation of K in leaf tissue which in turn improved the photosynthetic efficiency, translocation and accumulation of carbohydrates. Many workers have shown a direct relationship between K supply and fruits size. The results are in close conformity with the findings obtained by Koo (1974). The perusal of data presented Table 1 also revealed that highest level of potassium significantly improved juice, total soluble solids and ascorbic acid content of fruit. Among different levels of potassium K600g/plant showed maximum content of Juice (47.50%), TSS (11.50 Brix) and Vitamin C (55.00%) followed by K500g/plant while control recorded minimum amount. The acid content of fruit was decreased with increase in the K application (Table 1). The fruits treated with

Table 1. Effect of potassium on yield and quality of sweet orange cv. Mossamibi

Treatments (g/plant)	Yield (kg/tree)	Average fruit wt. (g)	Juice (%)	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100ml)
K_0	25.00	150.00	42.50	9.00	0.59	51.80
K_{100}	27.25	160.00	43.25	9.50	0.54	52.00
K_{200}	29.75	163.00	43.50	9.90	0.54	53.20
K_{200}	30.50	168.00	44.00	10.20	0.53	53.80
K_{200}	31.50	172.00	46.50	10.30	0.51	54.00
K_{200}	32.00	175.00	47.00	11.00	0.49	54.80
K_{200}	33.50	176.00	47.50	11.50	0.48	55.00
K_{200}	32.50	175.00	46.50	10.75	0.49	54.80
S.Em ±	1.02	1.89	0.74	0.25	0.04	0.68
C.D. (0.05)	2.67	4.95	1.94	0.65	0.11	1.80

K700g/plant recorded minimum (0.48%) acid content while control showed maximum (0.59%).

The increased solids content of fruit is due to many factors in which K play a specific role. Potassium improves the condition of photosynthesis in general. The first and important step in photosynthesis the conversion of solar energy into chemical energy (Photophosphorylation), is promoted by Potassium (Evans and Sorger, 1966). This energy is utilized for the reduction of CO2 to carbohydrates (Sugar). Due to positive influence of Potassium on stomata opening, it influences the flow of CO2 to the chloroplasts where photosynthesis takes place.

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YIELD COMPONENTS IN IMPROVEMENT OF CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

A set of 52 genotypes of chickpea were used to estimate genetic variability, interrelationships and path coefficients for 13 components. The seed yield was positively and significantly correlated with biological yield per plant, 100-seed weight, number of pods per plant, harvest index, number of secondary branches per plant and plant spread at both genotypic and phenotypic levels, while correlation of seed yield with days to 50% flowering, days to maturity and number of seeds per pod was negative and significant. Protein content showed negative and non-significant association with yield. Path analysis revealed the highest positive direct effects of biological yield per plant and harvest index towards seed yield. The most of the characters contributed indirectly through biological yield per plant and harvest index.

Key words : Chickpea, correlation, path analysis, yield components.

Improvement in yield and its components depends on the nature and magnitude of genetic variability present in the population. The genetic variability in conjunction with the total variability can be used in predicating the gain for a given selection intensity. Analysis of correlation coefficients between characters contributing directly or indirectly towards seed yield is a matter of considerable importance in exercising the selection programmes. A study of correlation alone is not enough to provide an exact picture of relative importance of direct and indirect influences of each of the component characters on seed yield. In this context, path coefficient analysis is an important tool for plant breeders in partitioning the correlation coefficients into the direct and indirect effects of independent variables on the dependent variable i.e. seed yield. Therefore, an attempt was made to gather information on these aspects in 52 genotypes of chickpea (*Cicer arietinum* L.).

MATERIALS AND METHODS

The genotypes differed significantly for all the 13 characters indicating the presence of wide variation in the material evaluated. The results on genetic variability parameters are presented in Table 1. The values of phenotypic coefficient of variation were higher than genotypic coefficient of variation indicating the influence of environmental factors. The highest genotypic coefficient of variation was observed for number of secondary branches per plant followed by 100-seed weight, seed yield per plant, biological yield per plant, number of primary branches per plant and number of pods per plant. Similar results were obtained by Maloo and Sharma (1987), Mishra *et al.* (1988) and Nimbalkar (2000). Johnson et al. (1955) suggested that the heritability and genetic advance when calculated together would be more useful in predicting the resultant effects of selection. In the present study, the estimates of high heritability coupled with high genetic advance were observed for number of secondary branches per plant, number of pods per plant, biological yield per plant and 100-seed weight, suggesting the existence of sufficient heritable variation and wider scope for selection of better types. These results are in conformity with those of Maloo and Sharma (1987), Mishra *et al.* (1988) and Nimbalkar (2000).

The association analysis revealed that, in general, the values of genotypic correlation were higher than their phenotypic correlations (Table 2) indicating the inherent association among the traits. Similar were the findings of Katiyar *et al.* (1981), Singh et al. (1999) and Kumar *et al.* (1999). In the present study, seed yield per plant was significantly and positively correlated with biological yield per plant, number of primary branches per plant, 100-seed weight, number of pods per plant, harvest index, plant height, number of secondary branches per plant and plant spread at both the genotypic and phenotypic levels. Such positive interrelationships between seed yield and these attributes have also been reported in chickpea by several researchers (Maloo and Sharma, 1987; Mishra *et al.*, 1988; Arora and Kumar, 1994; Singh *et al.*, 1997; Singh *et al.*, 1999). Thus, these attributes can serve as marker characters for yield improvement in chickpea. Seed yield exhibited significant but negative correlations with days to 50% flowering, days to maturity and seeds per pod. Since early maturity is considered as an important criterion this relationship seems to be in desirable direction.

Days to 50% flowering, which had significant and positive association with days to maturity, is an important component in identifying and deciding the duration of the crop. Both these traits had positive interrelationships with plant height, plant spread and number of seeds per pod. Such relationship may bring collective improvement in different characters and in turn, the seed yield. Biological yield per plant had positive and significant associations with plant height and plant spread at both genotypic and phenotypic levels as also reported by Arora and Kumar (1994). The number of primary branches and secondary branches per plant, number of pods per plant, biological yield per plant and harvest index were significantly and positively associated amongst themselves. The present findings strengthen the earlier findings of Katiyar *et al.* (1981), Sandhu *et al.* (1991) and Arora and Kumar (1994).

The results obtained for direct and indirect effects of different characters on seed yield are presented in Table 3. The path coefficient analysis revealed that biological yield per plant and and harvest index exhibited high and positive direct effects on seed yield per plant. Thus, these characters turned out to be the major components of seed yield. The maximum and positive direct

Table 1. Phenotypic and genotypic coefficients of variation, heritability (b.s.), genetic advance for various characters of chickpea

Characters	Range of variation	Mean	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability in broad sense	Genetic advance	Genetic advance expressed as per cent of mean
Seed yield/plant (g)	2.93-9.33	5.87	28.90	24.73	73.20	2.56	43.59
Days to 50% flowering	37.67-68.67	56.44	11.38	11.19	96.70	12.80	22.68
Days to maturity	86.67-107.67	97.33	5.25	5.12	95.00	10.00	10.27
Plant height (cm)	33.90-49.87	40.30	10.81	8.07	55.70	5.00	12.41
Plant spread (cm)	27.60-48.07	39.37	17.31	5.89	11.60	1.63	4.14
No. of primary branches/plant	1.13-3.40	1.96	27.89	21.21	57.80	0.65	33.16
No. of secondary branches/plant	1.73-7.73	3.68	35.16	32.27	84.20	2.25	61.07
No. of pods/plant	17.40-42.60	30.55	23.12	21.02	82.60	12.02	39.35
Biological yield/plant(g)	9.02-23.80	14.35	25.55	23.01	81.10	6.13	42.72
No. of seeds/pod	1.02-1.69	1.19	17.83	8.26	21.50	0.09	7.59
100-seed weight (g)	8.68-29.20	17.75	28.57	27.46	92.40	9.65	54.37
Harvest index (%)	32.84-52.41	40.93	15.58	8.41	29.20	3.83	9.36
Protein content (%)	19.19-25.07	21.75	6.85	6.42	87.70	2.69	12.37

Table 2. Genotypic (rg) and phenotypic (rp) correlation coefficients among 13 characters in chickpea

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Plant spread (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of pods/ plant	Biological yield/ plant (g)	No. of seeds/ pod (g)	100-seed weight	Harvest index (%)	Protein content (%)
Seed yield/plant (g)	rg	–0.337**	-0.382**	0.479**	0.402**	0.644**	0.450**	0.609**	0.948**	–0.585**	0.617**	0.481**	–0.008
	rp	–0.282**	-0.293**	0.342**	0.276**	0.431**	0.355**	0.554**	0.857**	0.125	0.534**	0.516**	-0.025
Days to 50% flowering	rg		0.949**	0.419**	0.602**	-0.368**	-0.556**	-0.421**	-0.139	0.367**	-0.035	-0.686**	-0.049
	rp		0.904**	0.395**	0.192	-0.274**	-0.498**	-0.383**	-0.129	0.193	-0.027	-0.349**	-0.043
Days to maturity	rg			0.402**	0.426**	-0.354**	-0.525**	-0.499	-0.217**	0.380**	-0.006	-0.599**	0.021
	rp			0.282**	0.154	-0.260**	-0.469**	-0.429	-0.180	0.185	0.006	-0.282**	0.021
Plant height (cm)	rg				0.968**	0.226*	-0.160	0.006	0.641**	-0.526**	0.648**	-0.302**	-0.008
	rp				0.489**	0.113	-0.096	0.055	0.489**	-0.145	0.489**	-0.160	-0.069
Plant spread (cm)	rg					0.049	-0.222*	0.236*	0.781**	-0.014	0.318**	-0.828**	0.143
	rp					0.019	-0.015	0.188	0.385**	0.033	0.144	-0.108	-0.012
No. of primary branches/plant	rg						0.418**	0.424**	0.386**	-0.422**	0.297**	0.870**	-0.024
	rp						0.315**	0.323**	0.270**	-0.130	0.226*	0.385**	0.005
No. of secondary branches/plant	rg							0.609**	0.375**	-0.313**	-0.036	0.680**	0.169
	rp							0.550**	0.245*	-0.195*	-0.023	0.355**	0.139
No. of pods/plant	rg								0.476**	-0.317**	-0.175	0.578**	-0.102
	rp								0.488**	-0.184	-0.132	0.279*	-0.110
Biological yield/plant(g)	rg									-0.453**	0.626**	0.178	0.034
	rp									-0.128	0.574**	0.019	-0.006
No. of seeds/pod	rg										-0.781**	-0.510**	-0.317**
	rp										-0.318**	-0.018	0.083
100-seed weight (g)	rg											0.137	-0.077
	rp											0.078	-0.099
Harvest index (%)	rg												-0.074
	rp												-0.022

*, ** significant at 5% and 1% levels, respectively.

Table 3. **Path-coefficient analysis showing direct and indirect effects of different characters on seed yield in chickpea**

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Plant spread (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of pods/ plant	Biological yield/ plant (g)	No. of seeds/ pod	100-seed weight (g)	Harvest index (%)	Protein content (%)	Genotypic correlation with seed yield/plant
Days to 50% flowering	0.047	-0.030	-0.018	0.027	-0.003	0.012	-0.008	-0.116	-0.002	-0.002	-0.244	0.000	-0.337**
Days to maturity	0.045	-0.032	-0.017	0.019	-0.003	0.011	-0.009	-0.180	-0.002	0.000	-0.213	0.000	-0.382**
Plant height (cm)	0.020	-0.013	-0.043	0.043	0.002	0.003	0.000	0.534	0.003	0.037	-0.107	0.000	0.479**
Plant spread (cm)	0.028	-0.014	-0.041	0.044	0.000	0.005	0.004	0.651	0.000	0.018	-0.294	0.000	0.402**
No. of primary branches/plant	-0.017	0.011	-0.010	0.002	0.009	-0.009	0.008	0.322	0.002	0.017	0.309	0.000	0.644**
No. of secondary branches/plant	-0.026	0.017	0.007	-0.010	0.004	-0.022	0.012	0.229	0.002	-0.002	0.242	0.000	0.450**
No. of pods/plant	-0.020	0.016	0.000	0.010	0.004	-0.013	0.019	0.396	0.002	-0.010	0.205	0.000	0.609**
Biological yield/ plant(g)	-0.007	0.007	-0.027	0.035	0.003	-0.006	0.009	0.832	0.002	0.036	0.063	0.000	0.948**
No. of seeds/ pod	0.017	-0.012	0.022	-0.001	-0.004	0.007	-0.006	-0.377	-0.005	-0.045	-0.181	-0.001	-0.585**
100-seed weight (g)	-0.002	0.000	-0.028	0.014	0.003	0.001	-0.003	0.521	0.004	0.057	0.049	0.000	0.617**
Harvest index (%)	-0.032	0.019	0.013	-0.037	0.008	-0.015	0.011	0.149	0.003	0.008	0.355	0.000	0.481**
Protein content (%)	-0.002	-0.001	0.000	0.006	0.000	-0.004	-0.002	0.029	-0.002	-0.004	-0.026	-0.003	-0.008

*, ** significant at 5% and 1% levels, respectively.

effects of biological yield per plant and harvest index have also been reported by Singh *et al.* (1990), Arora and Kumar (1994), Khorgade et al. (1995) and Singh *et al.* (1997). The positive direct effects of pods per plant and 100-seed weight were further supplemented by their positive indirect effects via biological yield per plant thus, giving rise to significant positive associations of these traits with seed yield. Similar results were obtained by Arora and Kumar (1994), Khorgade *et al.* (1995) and Singh *et al.* (1997). Plant spread, plant height, number of primary branches and secondary branches per plant and number of pods per plant had low direct effects but, supplemented yield indirectly through biological yield per plant, The residual effect was of very low magnitude suggesting that the majority of the yield attributes have been included in the path analysis.

Considering the genetic variability parameters, interrelationships and path analysis for seed yield and its components, an ideal plant type in chickpea will be the one with profuse branches, more number of pods per plant, high biological yield, harvest index and dwarf plant type accompanied with early flowering and maturity. Therefore, more emphasis should be given to those components while making selection for higher yield in chickpea.

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ASSESSMENT AND IMPACT OF BIPARENTAL MATING IN *BRASSICA CAMPESTRIS* L. VAR. BROWN SARSON

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ABSTRACT

Six sets of BIP-1 progenies, and their best selected recombinants in BIP-I-S3 generation of brown sarson *B. compestris* L. were studied for nine and seven characters, respectively. The estimates of σ^2 m was very low, as compared to σ^2 indicating pronounced genetic differences due to seed bearing parents than pollen parents. However, estimate of σfm^2 was comparatively higher, which showed inconsistency of various males over females and vice-versa. The order of dominance was in over-dominance range, which reflected importance of non-additive gene action. Wide range of recombinants for various characters appeared probably due to breakdown of repulsion phase linkages. Higher yielding recombinants showed that shifting of flowering period, increased length of floral axis, with more number of siliquae and increased primary and secondary branches were responsible for higher yield. Plants with high oil content were generally poor yielder. Selected plants progenies for yield and oil content indicated that both had intermediate biomass production but more than early parent and harvest index was comparable to early parent and better than national check. High oil yielding plant progenies showed 43 percent oil recovery through press expeller as compared to 33-35 per cent among parents and national check. High yielding plant progenies were superior to parents and national check for yield and oil recovery per hectare.

Key words : Biparental mating, biological yield, seed yield, harvest index, oil content.

Among the Indian Oleiferous Brassicae, *B. campestris* group and brown sarson in particular has considerable diversity, in the plant form, yield and adaptation with both self-compatible and self-incompatible types grown in the Indo-Gangetic and Brahmaputra plains. Its cultivation during Oct./Nov-March is in contrast to the spring and summer cultivation of the European counterparts. Even among the Indo-Gangetic material of brown sarson, each ecological group has a constellation of characters, related to growth habit and maturity. Above types had been under cultivation in marginal land under rainfed conditions. In addition, photo-thermo sensitivity and rising temperature during post flowering period have eroded considerable genetic variability. Breeding response for yield and its components are plateaued even cryptic genetic variability is tightly guarded by linkage restrictions (Mather and Jinks, 1941, Stebins, 1952, Arunachalam and Amirthadevarathnam, 1978). Among above types early group is represented by a bold seeded (1000-seed wt. 6.5 gm), a derivative of disruptive selection i.e. DSH 17 MD (Murty, 1969) and from late group a local collection i.e. Kanpur Tora had more primary and secondary branches with good root development, smaller in seed size. The complimentary characteristics of these two groups were found appropriate to develop new productive lines. Biparental mating was successful in breaking adverse linkages in B. campestris L. var. yellow sarson, (Singh and Murty, 1980) was adopted in F2's of above brown sarson to release desirable recombinants. An analysis pattern of genetic variation and performance of new recombinants is analysed and presented in this paper.

MATERIALS AND METHODS

The present study consisted of six Biparental (BIP) families generated from F2's of *Brassica campestris* L. var. brown sarson (self-compatible) lines. The late parent was kanpur Tora and the early was DSH 17MD. Their contrasting differences are given in Table 2. The BIP's were made from randomly selected plants (4 × 4 group) and mated in North Carolina (NC II) mating design. Six sets with each of 16 crosses were made. Experimental material was grown in randomized complete block design with three replications. Plot size was of two rows each of 5-meter length. The spacing was 60 cm between rows and 10 cm within the row. The experimental site was Division of Genetics, Indian Agricultural Research Institute, New Delhi. Observations were recorded on randomly selected five plants. Characters studied were height (cm) length of main axis (cm) number of siliquae on main axis, number of primary branches, number of secondary branches, number of seeds per siliqua, days of flowering, seed yield per plant (gm), oil content in per cent. Oil estimation was made through Pulse Nuclear Magnetic Resonance Spectrometer. Selection was exercised for yield and oil content. Best BIP-1 selected plants were advanced during next season and their progeny bulk were harvested in BIP-1. In ensuring season, BIP-2 were evaluated in a large plot size of 46.5 sq. meter. The characters examined were biological yield (by), seed yield (sy), harvest index (hi), oil recovery in percent through commercial press expeler methods, oil yield per hectare, days to flowering, days to maturity and total number of days available for seed filling stage. Variance components were calculated from the data of BIP-1 generation using the procedure (Comstock and Robinson, 1952).

RESULTS AND DISCUSSION

The ANOVA (analysis of variance) for nine characters have revealed that differences due to females in sets were highly significant for all the characters, however, differences due to males were significant only for four characters i.e. height, number of secondary branches, seed yield and oil content. Such differences of male and females group derived from the same F2's indicated pronounced female effect. The differences due to mxf interaction were also significant for all the characters except seeds per siliqua.

COMPONENTS OF GENETIC VARIANCES

The estimates of σ^2 m were negligible for most of the characters except for height, however, σ^2f was of higher magnitude as compared to σ^2m indicated that genetic differences due to seed parents were very high. The interaction components σ^2mf were of higher order than either of σ^2m or σ^2f for all the characters. This would be attributable to inconsistency of males over females and vice-versa. Order of dominance was in over dominance range, which reflected importance of non-additive component of genetic variance in this crop. This could be also due to F2's of two pure bred lines were used as compared to open pollinated varieties as demonstrated by a number of author (Gardener, 1963, Bhatia *et al.*, 1986, Nematullah & Jha, 1993). Some of the estimates of σ^2m were negative and similarly for yield. Such results may appear due to lack of random mating, large sampling error, or non-recovery of recombinants in F2's due to presence of tight repulsion phase linkage's and genotype-environment interaction. Random mating was followed, where as possibilities of other factors cannot be ruled out (Lindsey *et al.*, 1962, William *et al.*, 1965, Pant *et al.*, 1992). Parents with contrasting characters were involved initially (Table 1) and even then above results were observed. It appears that restriction by linkages through homozygous balances were overwhelming in self-compatible brown sarson. Above situation also observed probably due to intense human selection responsible for development of early type parent and natural selection created late parent and in the process of selection, additive variance might have been considerably exhausted, other workers encountered similar results in other crops (Linsdey *et al.*, 1962, Sharma *et al.*, 1979, Verma *et al.*, 1979). The presence of over-dominance, also appear due to repulsion phase linkage, however, their breakdown due to biparental mating give rise to unexpected superior recombinants as it happened for seed yield and oil content in this study (Arunachalam and Amirthadevarathnam, 1978).

Generation means

Among the six sets, there are differences in the recovery of progenies superior to the best parent and best BIP females. BIP were later (Table 1) than early parent by two to four weeks, showing that the yield improvement was associated with a shift in the flowering period. Since all the sets have yielded some progenies superior to early parent and their corresponding BIP female for not only yield and oil content but for number of primary and secondary branches and seeds per siliqua, the main yield components. Only four of the six sets have given some plants, which have higher number of siliqua on main axis. Thus improvement in yield has been mainly through the increasing number of branches. The progenies in sets II & V have some progenies superior to the better parent for seven of the nine characters, while set I & III have for six characters and set IV and VI for five characters. Sets II and V have progeny superior to the better parent for length of main axis, number of siliqua on main axis, which are other useful components for improving yield. Appearances of such progenies with marked change demonstrated that there was shift in character association and yield improvement had been affected by shifting flowering, through elongation of main axis and increase in branches was also showed by other workers (Verma *et al.*, 1979, Yunus and Paroda, 1982, Jensen and Federer, 1965).

Table 1. Parent, F1, BIP (parent), BIP mean and range for nine character in in *Brassica campestris* L. var. brown sarson

Entries	Height, cm	Length of main axis, cm	Number of siliqua on main axis	Number of primary branches	Number of secondary branches	Number of seeds per siliqua	Days to 50% flowering	Yield per plant gm	Oil content (%)
P-1 Kanpur tora	208	73	41	9	8	19	80	6	42
P-2 DSH17MD	92	38	20	5	5	17	36	8	44
F1	168	66	28	6	7	18	65	10	43
BIP Set I	169	64	38	10	7	20	64	9	56
Female parents mean									
Male parents mean	169	62	37	9	8	21	63	10	56
BIP's mean	169	63	36	10	6	21	65	9	55
BIP's range	153-276	57-72	32-43	6-13	3-13	19-23	59-73	5-15	19-57
BIP Set II	154	62	34	10	8	18	70	10	54
Female parents mean									
Male parents mean	156	61	35	8	7	17	72	8	54
BIP's mean	157	63	34	8	6	19	70	10	54
BIP's Range	143-170	53-74	30.41	8-14	5-13	18-22	60-80	7-13	49-58
BIP Set III	157	64	36	10	9	19	69	10	51
Female parents mean									
Male parents mean	160	65	37	10	7	20	71	12	50
BIP's mean	160	65	35	10	8	20	72	12	51
BIP's range	151-171	61-69	28-43	9-12	5-14	18-23	63-78	7-15	46-54
BIP Set IV	158	63	34	9	10	20	72	10	55
Female parents mean									

Contd...

Table 1. Contd...

Male parents mean	156	64	35	10	11	22	74	8	56
BIP's mean	160	64	34	10	9	20	72	10	55
BIP's range	149-174	56-72	29-40	7-12	3-19	17-34	62-102	7-14	49-58
BIP Set V	165	64	35	8	7	20	65	9	55
Female parents mean									
Male parents mean	163	61	36	9	8	16	64	8	54
BIP's mean	166	63	36	9	7	20	66	8	55
BIP's range	150-179	51-98	27-44	7-12	3-14	18-22	54-73	6-13	53-59
BIP Set VI	154	60	33	12	16	18	68	10	55
Female parents mean									
Male parents mean	159	61	34	12	12	20	69	10	54
BIP's mean	139-172	64-71	31-39	9-14	6-27	17-21	61-88	6-22	48-58
BIP's range	6-60	8-09	1.93	0.28	1.13	0.90	3.33	8.68	0.22

Table 2. Selected plants from BIP-I generation with high yield and trend of other characters in *B. campestris* L. var. brown sarson

Pedigree of selected BIP progenies	Yield per plant gm	Height cm	Length of main axis cm	Number of siliqua on main axis	Number of primary branches	Number of secondary branches	Number of seeds per siliqua	Days to 50% flowering	Oil content (%)
Set I									
N2 × M1	15.4	166	66	38	10	6	21	72	56.8
N3 × M3	14.3	181	63	42	13	6	21	73	58.2
N4 × M4	13.4	146	57	32	10	13	19	54	54.3
Set II									
N2 × M1	12.4	154	65	34	10	8	20	74	52.4
N3 × M3	11.4	161	57	33	10	8	22	62	56.0
N4 × M4	13.8	157	74	41	12	15	18	80	57.0
Set III									
N2 × M1	13.1	162	58	35	10	10	19	68	53.5
N3 × M3	15.2	157	68	40	11	8	24	72	46.8
N4 × M4	13.4	157	61	40	10	9	19	63	58.7
Set IV									
N2 × M1	12.6	161	69	33	12	8	21	72	55.6
N3 × M3	13.9	174	61	31	11	7	20	73	55.0
N4 × M4	14.4	158	73	34	7	7	9	71	50.0
Set V									
N2 × M1	13.3	164	66	35	7	5	21	68	56.9
N3 × M3	10.1	167	65	40	9	7	21	70	53.8
N4 × M4	13.4	174	70	45	8	5	22	73	57.2
Set VI									
N2 × M1	19.0	156	60	33	11	21	18	0.75	58.5
N3 × M3	15.5	167	71	39	14	31	19	86	50.0
N4 × M4	22.4	149	55	36	11	14	21	89	49.4
P1	6.0	208	73	41	9	6	19	80	42.3
P2	8.0	92	38	16	5	5	17	36	44.2

Table 3. Selected plants from BIP-I generation with high oil content and trend of other characters in *B. campestris* L. var. brown sarson

Pedigree of selected BIP progenies	Oil content (%)	Height cm	Length of main axis cm	Number of siliqua on main axis	Number of primary branches	Number of secondary branches	Number of seeds per siliqua	Days to 50% flowering	Yield per plant gm
Set I									
N1 × M1	58.8	186	72	42	12	13	23	60	8.8
N1 × M2	56.3	182	53	40	8	5	24	67	10.4
N3 × M3	58.6	206	72	42	11	5	22	69	10.1
Set II									
N3 × M1	56.6	162	74	39	9	12	19	74	11.0
N4 × M1	51.9	165	74	42	12	15	18	81	13.8
N4 × M2	59.5	170	53	31	12	11	20	60	8.6
Set III									
N2 × M2	54.6	162	63	43	9	10	20	69	8.4
N2 × M3	54.9	151	63	29	11	13	19	65	9.2
N4 × M2	54.3	163	70	33	11	14	20	76	8.6
Set IV									
N1 × M1	58.8	150	62	38	9	13	34	102	7.8
N3 × M3	58.6	166	72	36	13	16	18	79	11.5
N4 × M4	56.9	172	66	37	12	8	21	71	8.9
Set V									
N2 × M1	59.0	173	98	34	9	7	20	68	9.6
N3 × M1	58.6	164	60	35	11	13	20	64	8.7
N4 × M4	59.0	180	63	33	9	10	20	88	6.2
Set VI									
N2 × M2	58.5	156	60	34	11	21	18	75	19.0
N2 × M3	58.3	173	68	35	13	11	18	72	12.6
N4 × M5	57.2	162	65	34	16	12	20	66	6.4

Table 4. Comparison of parents, best BIP-1-S3 for seed yield oil content and against national check in *B. compestris* L. var. brown sarson

Source	Total biological yield kg/ha	Total seed yield kg/ha	Harvest index %	Oil recovery %	Oil yield kg/ha	Days to 50% flowering	Days to maturity	Seed filling period
Kanpur Tora	12251	1187	9.9	33	391.7	80	135	55
DSH 17 (P2) MD	5445	816	15.0	35	285.6	36	105	69
BIP (hy)	8167	1232	15.1	36	443.5	75	125	50
BIP (HOC)	6534	980	11.9	43	424.4	65	120	55
Pusa Kalyani (check)	10890	969	8.9	34	416.6	50	115	65

Shift in character association due to biparental mating in Superior yielding BIP progenies : The characteristic of the selected plants in BIP-I generation, which has the highest yield within each set, is given in (Table 2). The superior yielding selections have a combination of attributes equal or superior to the better parent for all the characters except height and length of main axis. Some of the plants were almost equal to the late parents for length of main axis with nearly 80 percent increase over early parent but 50 to 100 percent increase in height. Thus they combine the more number of branches and length of main axis of the late parent and higher oil content than early parent. They were also much later in flowering, but earlier than late parent by one to two weeks. Selection on the basis of oil content (Table 3) has invariably resulted lower yield but still better than early parent. The data indicated that higher yield could be obtained with small but significant increase in oil content and somewhat intermediate range for days to flower. Appearances of such recombinants through BIP mating have been observed by other workers (Singh & Murty, 1980, *et al.*, 1992, Yunus and Paroda, 1982).

Impact of selection

The evaluation of best BIP-I-S3 from set V and VI for oil content and seed yield in large plot (Table 4) revealed that the total biomass production in both the cases was more than early parent, but lower-than late parent. However, BIP (hy) selection was superior to both the parents for yield and harvest index and yielded more oil per hectare basis as compared to parents and national check. The BIP (hoc) selection showed low yield and harvest index but oil recovery percent was spectacular. Infect, yield and oil improvement programme such rare recombinants for oil content would be of great use as non-recurrent parent to increase oil yield. When yield is plateued, use of biparental approach appears to be one of the best alternative to bring changes as demonstrated in this study.

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HETEROSIS AND INBREEDING DEPRESSION FOR YIELD AND ITS ATTRIBUTES IN CHICKPEA

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ABSTRACT

In 10 crosses of chickpea (*Cicer arietinum* L.) heterosis over first parent, second parent and mid-parent in F_1 and inbreeding depression in F2 were estimated in the winter season (1998-99) for eight yield attributes viz; days to first flower, days to 50% flowering, plant height, days to maturity, number of pods per plant, number of seeds per pod, seed yield per plant and 100-seed weight. A range of significant heterosis and inbreeding depression was observed for various traits in different crosses. The heterosis and inbreeding analysis suggested that early and high yielding segregants can be selected from crosses *viz*; Phule G 5 × DCP 92-39, Phule G 5 × ICC 4958 and Phule G 5 × H 82-2 and high yielding with good bio-mass from Phule G 5 × IPC 71.

Key words : Heterosis, inbreeding depression, chickpea, *Cicer arientinum* L.

Chickpea (*Cicer arietinum* L.) is a highly self pollinated crop and the scope for the exploitation of the vigour is quite remote as hybrid seed can not be produced economically unless mechanism of cross-pollination is introduced. However, in autogamous crops like chickpea, where hybrid vigour/heterosis accompanied with little or no inbreeding depression, can be utilized for developing pure lines by fixing additive and additive × additive type of variances. Thus, the study of heterosis and inbreeding depression will have direct bearing on the adoption of breeding methodology to be employed for varietal improvement in this crop.

MATERIALS AND METHODS

A set of 10 crosses was made using Phule G 5 (agronomic base) and 10 donor parents (H 82-2, ICC 4958, DCP 92-1, ICCV 10, DCP 92-39, PDG 84-16, KWR 108, PBG 1, L 144 and IPC 71) during 1996-97. Parents, F_1 s and F_2 s were raised in a completely randomised block design with 3 replications in the winter season of 1998-99 at Indian Institute of Pulses Research, Kanpur. Standard agronomic practices were followed for raising the crop using pre-plant irrigation. Five randomly selected plants were tagged in each treatment and replication for recording observations on days to first flower, days to 50% flowering, plant height, days to maturity, number of pods per plant, number of seeds per pod, seed yield per plant and plant height. Heterosis over first parent, second parent and mid-parent in F1 and inbreeding depression from F1 to F2 were calculated following Mather and Jinks (1971) with the help of statistical package for agricultural research (SPAR 1).

RESULTS AND DISCUSSION

Performance of F1 hybrids as compare to their respective parents (first parent) and inbreeding depression from F1 to F2 generation for eight characters are provided in Table 1.

In general, the hybrid combinations which showed higher estimates of heterosis also exhibited higher inbreeding depression (Deshmukh and Bhapkar, 1982 and Shinde and Deshmukh, 1990). Range of heterosis in crosses over first, second and mid-parent were observed for all the eight yield attributes and seed yield per plant. Only one cross i.e. Phule G 5 × H 82-2 showed significant heterosis over second parent indicating that hybrid was early in producing first flower than the second parent. Two crosses displayed significantly negative heterosis for days to 50% flowering but with positive inbreeding depression, indicating that it provide chances to select early segregants in F2 generation for days to 50% flowering. Nine crosses displayed significant heterosis over mid-parent, five over first parent and seven over second parent for plant height. Phule G5 × IPC 71 displayed significant negative heterosis over first parent and mid-parent, indicating that taller recombinants may be selected from this cross. Similarly for cross Phule G 5 × PDG 84-16 where, heterosis over second parent (13.07) and mid-parent (5.82) were highest. Heterosis over second parent and mid-parent was significant in eight and seven crosses, respectively. Crosses involving early maturing parents ICC 4958, DCP 92-39 and PDG 84-16 showed significant heterosis and inbreeding depression. Since, heterosis over first parent (Phule G 5) was negative for three crosses involving ICC 4958, DCP 92-39 and PDG 84-16 and positive over second parent and mid-parent indicated that from these three crosses early maturing segregants can be recovered. Second parent heterosis for days to maturity ranged from 0.01 to 22.33 per cent, whereas inbreeding depression ranged from -4.00 to 4.67 percent. Eight crosses showed significant positive heterosis over second parent whereas only two crosses (Phule G 5 × H 82-2 and Phule G 5 × DCP 92-1) displayed significant and positive heterosis over first, second and mid-parent. It indicated that recombinants with high number of pods per plant may be selected from these crosses in later generations. The heterosis over second parent for pods per plant ranged from 7.0 to 31.0 percent.

Heterosis for number of seeds per pod was of low magnitude. Only one cross (Phule G 5 × DCP 92-1) showed significant negative heterosis over second and mid-parent for number of seeds per pod. It may be due to the fact that less variation was present among genotypes for this character. Heterosis over first parent (large seeded) for 100 seed weight ranged from -11.20 to 5.40 per cent. Cross Phule G 5 × H 82-2 exhibited significant positive heterosis over first, second and mid-parent indicating that segregants with better seed size can be isolated from this cross. Six crosses out often displayed significant positive heterosis over superior parent whereas positive inbreeding depression was observed for three crosses. Low estimates of heterosis were

Table 1. Heterosis and inbreeding depression for eight characters in chickpea

Crosses	Days to first flower				Days to 50% flowering			
	FP	SP	MP	ID	FP	SP	MP	ID
Phule G 5 × H 82-282-2	0.33	-2.33*	-1.00	1.00*	-1.33	-1.67	-1.50	1.33
Phule G 5 × ICC4958	-7.33*	17.00*	4.83*	4.33*	-12.67*	10.33*	-1.17	1.00
Phule G 5 × DCP92-1	3.33*	1.33	2.33**	2.33*	3.67*	5.00*	4.33*	6.00*
Phule G 5 × ICCV 10	3.33*	1.33	2.33	6.33*	-1.33	-3.67*	-2.50	4.33*
Phule G 5 × DCP 92-39	-0.33	25.33*	12.50*	8.00*	-2.67**	20.33	8.83*	9.00*
Phule G 5 × PDG 84-16	-1.67	29.67*	14.00*	12.00*	-2.33	28.33*	13.00*	16.33*
Phule G 5 × L 144	1.67	2.67	2.17	2.67**	-1.67	-2.00	-1.83	2.67
Phule G 5 × KWR 108	0.33	4.33*	2.33	0.67	-1.67	-0.67	-1.17	-2.33
Phule G 5 × PBG 1	8.00*	9.67	8.83*	-1.00	5.33*	6.00*	5.67*	-1.00
Phule G 5 × IPC 71	1.67	2.67**	2.17**	-0.33	0.67	-5.67*	-2.50*	1.00
Phule G 5 × H 82-2	0.80	6.53*	3.67*	-1.03	-2.00*	0.01	-1.00	0.67
Phule G 5 × ICC4958	5.73*	0.37	3.05*	2.87*	-6.33*	16.00*	4.83*	2.67**
Phule G 5 × DCP92-1	5.27*	3.80*	4.53*	0.27	1.33	5.33*	3.33*	0.67
Phule G 5 × ICCV 10	1.63	5.90	3.77*	3.03*	-0.67	3.67*	1.50	-0.33
Phule G 5 × DCP 92-39	7.83*	-1.27	3.28*	-0.90	-2.33	22.33*	10.00*	4.67*
Phule G 5 × PDG 84-16	-1.43	13.07*	5.82*	6.20*	-6.33*	20.33*	7.00*	2.33**
Phule G 5 × L 144	7.37*	-0.70	3.33*	0.17	1.67	0.33	1.00	-0.67
Phule G 5 × KWR 108	0.47	4.60*	2.53*	2.07	2.67*	4.67*	3.67*	1.00
Phule G 5 × PGB 1	-0.43	3.17*	1.37	1.77	5.67*	4.67*	5.17*	-1.00
Phule G 5 × IPC 71	-11.60*	5.37*	-3.12**	7.50*	7.67*	14.00*	10.83*	-4.00*
Phule G 5 × H 82-2	11.33*	17.67*	14.50*	8.67*	0.03	-0.23	-0.10	0.07
Phule G 5 × ICC4958	11.00*	21.67*	5.33*	15.33*	-0.13	0.17	0.02	0.03
Phule G 5 × DCP92-1	6.67*	16.67*	11.67*	4.33*	-0.33	-0.40*	-0.37*	-0.03
Phule G 5 × ICCV 10	-3.67*	13.67*	5.00*	0.00	0.03	-0.07	-0.02	-0.03
Phule G 5 × DCP 92-39	-17.67*	21.33*	1.83	-0.67	-0.10	0.13	0.02	0.33
Phule G 5 × PDG 84-16	-15.67*	18.33*	1.33	6.67*	0.00	-0.13	-0.07	-0.03
Phule G 5 × L 144	2.33*	23.33*	10.50*	19.00*	-0.23	-0.07	-0.15	-0.03
Phule G 5 × KWR 108	8.33*	16.67	12.50*	-1.00	0.07	-0.07	0.00	0.27

Contd...

Table 1 Contd...

Phule G 5 × PGB 1	-1.00	31.00*	15.00*	-0.67	-0.13	-0.13	-0.13	-0.03
Phule G 5 × IPC 71	11.00*	7.00	9.00*	31.00*	-0.27	-0.30	-0.28	0.07
Phule G 5 × H 82-2	1.73	3.10**	2.42*	0.23	1.10**	13.17*	7.13*	0.97
Phule G 5 × ICC4958	-1.70**	1.83*	0.07	-5.67*	-0.23	0.83	0.30	-0.10
Phule G 5 × DCP92-1	1.43*	0.87	1.15	2.93*	0.60	0.53	0.57	-0.07
Phule G 5 × ICCV 10	3.63	2.00	1.32	0.60	-9.20*	1.87**	-3.67*	0.07
Phule G 5 × DCP 92-39	0.93	2.13*	1.53	2.23*	5.40*	-3.27*	1.07	2.10*
Phule G 5 × PDG 84-16	-3.67*	0.93	-1.37*	4.50*	-9.77*	3.73*	-3.02*	0.80
Phule G 5 × L 144	-3.10*	-1.00	-2.05*	-6.73*	0.70	0.73	0.72	2.03*
Phule G 5 × KWR 108	0.37	0.27	0.32	-0.47	-5.97*	4.70*	-0.63	-0.07
Phule G 5 × PGB 1	-1.00	1.43	0.22	3.20*	-8.37*	3.73*	-2.32*	1.53
Phule G 5 × IPC 71	-1.87*	2.23*	0.18	1.47	-11.20*	3.77*	-3.72*	3.30*

*, ** Significant at 5% and 1% level of significance, respectively.

FP = First parent, MP = Mid parent, SP = Second parent; ID = Inbreeding depression

observed for seed yield per plant. Significant positive heterosis over second parent was observed for four crosses. Phule G 5 × ICC 4958 displayed positive heterosis over second parent and significant negative inbreeding depression. Phule G 5 × L 144 also displayed significant negative inbreeding depression. The low magnitude of heterosis were expected in this study because Phule G 5 was a high yielding and better adaptable released variety whereas others were not adapted to growing conditions of Kanpur or they were not as high yielding as Phule G 5.

The positive heterosis over second parent for yield in most of the yield component. Since yield per se is not an independent character but is contributed by its components and thus its heterotic expression is nothing but the combined heterotic expression of its components. In the present material and crosses could be usefully handled for developing the pure lines performing at par or better than the F_1 frosses from where they could be derived. Many workers also suggested fixation of heterosis in advance generations of chickpea where it is controlled by additive × additive gene effects. In Phule G 5 × ICC 4958 for seed yield per plant significant and positive heterosis over second parent was associated with significant and negative inbreeding depression which could be due to the occurrence of high proportion of transgressive segregants for yield in this cross. However, percent-inbreeding depression for pods per plant and plant height was 15.33 and 2.87%, respectively.

Similar results has been reported by Kunadia and Singh (1980), Shinde and

Deshmukh (1990), Arora (1990), Kamata et al. (1996) and Singh and Ocampo (1997). Singh et al. (2000) also reported average inbreeding depression for seed yield per plant and other characters with low to high magnitude of heterosis over better and mid-parent.

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GROWTH PERFORMANCE AND CONTRIBUTION OF DIFFERENT SEED AGENCIES IN HARYANA STATE WITH REFERENE TO FOUNDATION SEEDS OF CEREALS

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ABSTRACTS

The study pertains to Haryana state for the period from 1990-91 to 1999-2000. Foundation seed is the first generation seed from breeder seed. The growth performance of HSDC, IFFCO and KRIBHCO in foundation seed of cereals was not satisfactory and growth performance of CSF was 2.52 per cent per annum. The growth performance of NSC and HAU were reported to be deteriorating at a fast rate. The growth rate of private seed firms was reported to be very high. The overall growth rate of foundation seed of cereals in the state was improving at the rate of 3.6 per cent per annum. The growth performance of government sub-sector in foundation seed of creals was poor and showing declining trend. The growth performance of cooperative sub-sector in total foundation cereals could not maintain its status quo and showed slightly declining trend. The growth rate of private sub-sector was found to be 16.46 per cent per annum and that was very high over the period of last decade. The overall growth performance of total foundation seed of cereals in the state was moderate over the period of last decade. The contribution of HSDC, CSF, NSC, IFFCO and KRIBHCO in total certified wheat/cereals' seed and foundation wheat/cereals' seed in the state were maintained consistently upto year 1995-96 but their contributions declined drastically with the establishment of World Trade Organization. But the contribution of private sub sectors increased slightly upto the year 1995-96 and increased rapidly after the establishment of World Trade Organization. The contributions of government and cooperative sub-sectors decreased slightly upto the year 1995-96 and went down drastically after the establishment of World Trade Organization. The contribution of private sub-sector increased slightly upto the year 1995-96 and increased rapidly after the establishment of World Trade Organization in total certified wheat/cereals' seed and total foundation wheat/cereals' seed in the state over the period of last decade.

Key words : Seed agencies, foundation seed, cereals.

Since agriculture is a biological industry, its success depends upon use of the good quality seed. The pace of progress in food production will largely depend upon the speed with which high quality seeds of agricultural crops are generated and made available to farmers as and when required. The new agricultural policy emphasized private sector participation in contract farming. Contract farming is practiced as an alternative for state supported extension services and acts as vehicle for the technology transfer, agro-industrial integration and modernization of agriculture of peasants including small landholders. Foundation seed is the first generation seed from the breeder seed, usually produced under contract by a Foundation Seed Organization. After the initiation of New Economic Policy, there is an influx of large number of private seed companies both indigenous and multi-national in nature in large are operating in the state. Production of foundation seed of creals by co-operative, governemnt and private seed agencies are flourishing in the state. Hence it becomes important to see the direction of change of cereals foundation seed production agencies in the state in view of the liberalization, globalization and privatization policies introduced in the country to cope with changing global scenario. The study would be useful for researchers, planners and policy makers in the formulation of policies for overall development of seed industry.

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METHODOLOGY

The present study makes use of secondary data for the period 1990-2000. Secondary data of foundation seed of cereals were collected from the annual reports of the Haryana Seed Development Corporation (HSDC) and the Haryana State Seed Certification Agency (HSSCA). For computing the trend in production of foundation seed of cereals, the compound growth rate analysis was employed by fitting exponential type of function.

The equation of the exponential function is:

$$Y = a.bt$$

where,

Y = area/production/productivity

t = time variable in years

a = intercept indicating Y in the base period (t=0)

b = regression coefficient

as :

$$\log y = \log a + t \log b$$

The compound growth rate (CGR) has been calculated as :

$$CGR\ (\%) = (\text{Anti}\ \log b\text{-}1) \times 100$$

To know the magnitude of variation among the observations, coefficient of variations of average expected production and actual production obtained were calculated with the help of following formula :

$$C.V.\ (\%) = S.D.\ /\ \text{Mean} \times 100$$

where, S.D. is standard deviation and mean is arithmetic mean

Simple tabular and conventional percentage analysis was used for determining contributions of different agencies in total contract foundation seed production of wheat.

RESULTS AND DISCUSSION

The compound growth rates of HSDC, Central State Farm (CSF), Indian Farmers' Fertilizer Co-operative Limited (IFFCO) and Krishi Bharti Co-operative Limited (KRIBHCO) were -9.3 per cent, 2.52 per cent, -2.5 per cent and -2.5 per cent per

Table 1. Agencies-wise growth rates of total foundation seed of cereals in the state during 1990-91 to 1999-2000

Agencies	R^2	df	F	Sig F	b_0	b_1	CGR	CV
HSDC	0.152	8	1.43	0.266	3497.80	0.907	-9.3^{Ns}	47.53
CSF	0.039	8	0.32	0.586	3730.22	1.0252	02.52^{Ns}	27.03
NSC	0.705	8	19.13	0.002	10631.5	0.7448	-25.52*	69.8
HAU	0.905	8	76.41	0.000	10521.7	0.8542	-14.58*	42.91
IFFCO	0.086	8	0.75	0.411	606.52	0.9750	-2.5^{Ns}	26.29
KRIBHCO	0.033	8	0.27	0.618	429.357	0.9750	-2.5^{Ns}	46.18
Private	0.955	8	169.06	0.000	7029.41	1.1646	016.46*	46.28
Total	0.560	8	10.17	0.013	27606.3	1.0360	03.6*	14.74

*Significant at 1% level, Ns : Non significant

annum, respectively and found statistically non significant. It could be concluded that growth performance of these agencies except CSF were negative (Table 1). This might be due to mismanagement, apathetic attitude of government officials towards seed farmers and rigid and lack of transparent seed policy. The growth rates of National Seed Corporation (NSC), Haryana Agricultural University (HAU) and private agencies were found to be -25.52 percent, -14.58 percent and 16-46 per cent, respectively and were found statistically significant. The R^2 values of these agencies were 0.70, 0.90 and 0.95. It could be concluded that the growth performance of NSC and HAU had declined significant over a period of last decade especially after the establishment of World Trade Organization. But the growth rate of private sub-sector in the last decade was very high. The overall growth rate of foundation seed of cereals in the state was 3.6 per cent per annum and found statistically significant and its R^2 value was 0.56. It could be concluded that growth performance of foundation seed of cereals in the state was moderate. The C.V. of seed production of farmers attached with HSDC, NSC, HAU, KRIBHCO and private seed firms were comparatively high, it means that the chances of acceptance and rejection of seed production both at field level during strict seed production procedures and at laboratory level due to stringent quality parameters adopted by the officials of the HSSCA in foundation seed of cereals.

The compound growth rate of government sub-sector in total foundation seed of cereals was observed to be -9.13 per cent per annum over a decade and found statistically significant and its R^2 value was 0.792 (Table 2). It could be concluded that overall growth performance of government sub-sector in foundation seed industry was poor and showing declining trend in total foundation seed of cereals over a period of last decade. The compound growth rate of cooperative sub-sector was computed to be -2.55 per cent per annum and found statistically non-significant and R^2 value was 0.082. It could be concluded

Table 2. Sub-sectors-wise growth rates of total foundation seed of cereals in the state during 1990-91 to 1999-2000

Sub-sectors	R^2	F	Sig F	b_0	b_1	CGR
Government	0.792	30.41	0.001	24194.90	0.9087	-9.13*
Cooperative	0.082	0.72	0.422	1054.20	0.9745	-2.55^{Ns}
Private	0.955	169.06	0.000	7029.41	1.1646	16.46*
Total	0.560	10.17	0.013	27606.30	1.0360	3.60*

*Significant at 1% level, Ns : Non significant

that growth performance of cooperative sub-sector in total foundation seed of cereals could not maintain its status quo and showed slightly declining trend over the study period. The growth rate of private sub-sector was found to be 16.46 per cent per annum and found statistically significant and its R^2 value was 0.955, which was very high. It revealed that the growth performance of private sub-sector in total foundation seed of cereals was very high. The overall growth rate of total foundation seed of cereals in the state was 3.60 per cent and found statistically significant at 1% level and its R^2 value was 0.560. It is concluded that the growth performance of overall foundation seed of cereals in the state was showing moderate increase.

The contribution of HSDC was 8.19 per cent in the year 1990-91 and marginally increased upto 10.10 per cent in the year 1996-97. But after the establishment of WTO, there was a drastic reduction in contribution of HSDC in total foundation seed of cereals in the state, and declined upto 3.77 per cent in the year 1999-2000. The contribution of CSF in total foundation seed of cereals in the state in the year 1990-91 was 18.69 per cent and came down to 13.47 per cent in the year 1999-2000. Since land area allotted here for seed production in government farm remained consistent, there was not much drastic reduction as was observed in HSDC. The contribution of NSC in 1990-91 was 17.75 per cent and retained its consistent contribution upto the year 1995-96. But after the establishment of WTO, its share declined drastically and reached upto nearly 1.86 per cent in the year 1999-2000. The contribution of HAU in total foundation seed of cereals was 24.23 per cent in 1990-91 and declined to 5.96 per cent in the year 1999-2000. The contribution of IFFCO and KRIBHCO in total foundation seed of of cereals in 1990-91 were nearly 1.94 per cent and 1.3 per cent, respectively and they retained their contribution through out the study period. The contribution of private sub-sector was 27.90 per cent in the year 1990-91 and it reached 46.79 per cent in the year 1995-96. But after the establishment of WTO, the share of private sub-sector increased and reached upto 72.94 per cent in the year 1999-2000. This might be due to change in incentive price policy of HSDC and which reduced the incentive prices from 33.3 percent to 22.5 percent over and above the procurement prices to the farmers attached with government sub-sector after the year

Table 3. Agencies-wise contribution (%) in total foundation seed production of cereals in the state during 1990-91 to 1999-2000

Years	HSDC	CSF	NSC	HAU	IFFCO	KRIBHCO	Private	Total
1990-91	8.19	18.69	17.75	24.23	1.94	1.30	27.90	100
1991-92	12.09	11.51	16.64	23.74	2.31	1.65	32.07	100
1992-93	9.82	14.95	15.95	23.10	1.04	1.31	33.83	100
1993-94	6.79	13.54	14.90	20.53	2.15	0.95	41.14	100
1994-95	5.24	5.60	13.75	19.91	2.22	0.84	52.42	100
1995-96	9.79	14.18	13.98	12.77	1.34	1.16	46.79	100
1996-97	10.10	13.29	1.06	10.77	1.89	2.15	60.74	100
1997-98	0.93	16.09	2.15	7.42	1.35	1.40	70.67	100
1998-99	5.95	11.47	1.64	4.83	0.99	0.44	74.68	100
1996-2k	3.77	13.47	1.86	5.96	1.15	0.85	72.94	100

1997-98. This encouraged the active participation of private sub-sector in total foundation seed of cereals in the state.

The contribution of government sub-sector in the year 1990-91 was 68.86 per cent in total foundation seed of cereals in the state and its contribution decreased slightly and reached to 50.71 per cent in the year 1995-96. After the establishment of TWO, its share declined drastically and reached 25.06 per cent in the year 1999-2000. The contribution of cooperative sub-

Table 4. Sub-sectors-wise contribution(%) in total foundation seed production of cereals in the state during 1990-2000

Year	Government	Cooperative	Private	Total
1990-91	68.86	3.24	27.90	100
1991-92	63.97	3.96	32.07	100
1992-93	63.82	2.35	33.83	100
1993-94	55.76	3.10	41.14	100
1994-95	44.52	3.06	52.42	100
1995-96	50.71	2.50	46.79	100
1996-97	35.22	4.04	60.74	100
1997-98	26.58	2.75	70.67	100
1998-99	23.89	1.43	74.68	100
1996-2k	24.06	2.00	72.94	100

sector in 1990-91 was 3.24 per cent and its contribution slightly increased upto the year 1996-97. After the establishment of WTO, its share decreased to 2.00 per cent in the year 1999-2000. The contribution of private sub-sector in total foundation seed production of cereals was 27.90 per cent in the year 1990-91 and had increased to 72.94 per cent in the year 1999-2000. The contribution of private sub-sector increased rapidly after the establishment of WTO in the year 1995-96. The rules and regulations of WTO encouraged the active participation of private sub-sector in foundation seed business of cereals.

The study concluded that the private sub-sector flourished at the expanse of government and co-operative sub-sectors. The overall production of foundation seed of cereals in the state has increased significantly over the study period. Thus rules and regulations of World Trade Organization promoted the private sub-sector participation in farming through contract foundation seed production of cereals.

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POST HARVEST LOSSES OF VEGETABLES : AN ASSESSMENT

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ABSTRACT

In the present situation of increasing burden of population and industrialization, the reduction in losses is a complimentary means of increasing the availability of perishable vegetables. Varanasi district has been surveyed to assess the post harvest losses of vegetables in both physical and economic terms at different stages during 99-00 and 2000-01. The multistage stratified random sampling has been employed to estimate losses at wholesale, retailer and farm level. The estimates are developed for losses at transportation, storage and sorting level. It is evident from the losses that the overall losses varies up to 20% in vegetables viz. tomato, cabbage, cauliflower and chillie. The estimated loss varied from 10%, 14% and 20% for tomato crop at wholesale, retailer and farm level respectively. During sorting process maximum loss was observed in cabbage and at retailer level for tomato. The more moisture content of tomato is responsible for maximum loss at storage.

Key words : Postharvest losses, loss estimation, storage life, vegetables.

With suitable agro-climatic conditions prevailing in the country, India has been the second largest producer of vegetables in the world accounting, for 14% of the total world production of vegetables (Verma *et al.*, 2002). Though there has been a considerable increase in the production of vegetables, the per capita availability is still less than recommended levels. One of the main reasons for low availability is the enormous post harvest loss (Bose *et al.*, 1993). The post harvest losses affect both the producers as well as consumers and in the present situation of increasing burden of population and industrialization, the reduction in losses is a complimentary means of increasing the availability of perishable vegetables. During the process of distribution and marketing, substantial losses are incurred which range from a slight loss of quality to total spoilage (Kumar and Arora, 1999). Postharvest losses may occur at any point in the marketing process, from the initial harvest through assembly and distribution to the final consumer. The causes of losses are many : physical damage during handling and transport, physiological decay, water loss, or sometimes simply because there is a surplus in the market place and no buyer can be found (Pantastico and Bautista, 1976). Different types of losses occur during the production as well as post harvest cycle of the crop and has a variety of causes. It follows that effective and sustainable control of post harvest losses should be an integrated approach taking into account health, economics and practicality of situation (Gauraita, 1997).

Loss estimation is a tedious task and in perishables the estimates are not as precise as in the durable commodities. The figures of the losses do not add precisely because the causes of wastage depend on degree (Thompson, 1996). The losses are highly locality specific and level of loss acceptable in rural market differs greatly from that acceptable in commercial post harvest sector (Madan, 1991). Studies of post harvest losses of vegetables identified losses in the range of 20 to 40% (Gauraita, 1999). A study of varietal differences in postharvest losses of tomato found interesting differences between varieties. This implies that plant breeding may be a useful approach to loss prevention. Breeders have to consider the storage life after harvest in addition to the field performance of cultivars. Common causes of post harvest losses are diverse, but the most common are over ripening, disease, harvesting when the fruit is too immature and mechanical damage. The post harvest losses are high because of the inherent difficulty of collecting and transporting small quantities of produce from numerous small farms, and trying to collect these into a large enough quantity for efficient domestic marketing (Subrahmanyan, 1991). A great deal of research and training is needed if prevention measures are to be improved. The need for post harvest improvement has been found promising by the fact that in developing countries where there is a poor infrastructure and a lack of marketing facilities, posthavest losses of fresh produce range from 20 to 50% (Waheed *et al.*, 1986).

MATERIALS AND METHODS

In order to assess the post harvest losses of vegetables in both physical and economic terms at different stage the Varanasi district has been surveyed during 1999-2000 and 2000-01. The wholesale vegetable markets in Varanasi were observed as Paharia, Chandua Satti, Sunderpur, Rajatalab, Punchkoshi and Kisan Mandi (Kachhawa). Retail Markets are found to be area specific and large markets were observed at : Sunderpur, Rajatalab, Jallalipatti, Pandeypur, Lanka and Chanduia Satti. The method of personal interview has been employed to collect desired information via already designed questionnaire. The secondary information provided by Department of Horticulture, Varanasi have been utilized to identify suitable major vegetables producing areas as well as markets. The multistage stratified random sampling has been employed to estimate losses at wholesale, retailer and farm level.

RESULTS AND DISCUSSION

Both quantitative and qualitative losses of extremely variable magnitude occur at all stages in the post harvest system from harvesting, through handling, storage and marketing to final delivering to the consumer. It is evident from the tables that the overall losses varies up to 20% in vegetables viz. tomato, cabbage, cauliflower and chilli. The estimated loss varied from 10%, 14% and 20% for tomato crop at wholesale, retailer and farm level respectively. During sorting process maximum loss was observed in cabbage and at retailer level for tomato. The more moisture content of tomato is responsible for maximum loss at storage also. However, with the availability of adequate cold storage facilities, better means of packing and proper transport, the losses at harvesting, packing, transportation, marketing can be reduced.

A general picture of the rate of post harvest losses of horticulture crops in each country can be obtained from the Food Balance Sheet by calculating the difference between total production and total consumption. However, this kind of average figure does not provide much practical information for planning and implementing programs at a local level for a specific commodity. What is needed is an assessment of the loss rate and identification of specific problems for specific commodities. If loss rates are found to be very high in a specific area, it should be possible to find the cause and solve the problem. Because farmers tend to focus on production and overlook the role of post harvest technology. The grower should be made aware that small changes in attitudes toward the prevention of post harvest losses may profit farmer more than changes in the techniques of the marketing chain. The concepts and methodology for studying postharvest losses need to be refined and standardized, so that different studies can give comparable data. Secondly, policy makers need to know more about the costs and benefits of investment for loss reduction.

Table 1. Percentage losses at various levels

Vegetable	Whole sale	Retail	Farm level
Tomato	10.0	14.0	20.0
Cabbage	1.0	15.0	12.0
Cauliflower	1.0	13.0	12.0
Chilli	2.0	2.0	1.0

Table 2. Losses due to transportation (%)

Vegetable	Whole sale	Retail	Farm level
Tomato	3.5	1.0	5.0
Cabbage	>0.5	3.0	2.0
Cauliflower	>0.5	3.0	2.0
Chilli	>0.5	>0.5	1.0

Table 3. Sorting induced losses (%)

Vegetable	Whole sale	Retail	Farm level
Tomato	>0.5	12.0	>0.5
Cabbage	>0.5	13.0	10.0
Cauliflower	>0.5	10.0	10.0
Chilli	>0.5	3.0	>0.5

Table 4. Storage losses of vegetables

Vegetable	Whole sale	Retail	Farm level
Tomato	7.0	>0.5	>0.5
Cabbage	>0.5	>0.5	>0.5
Cauliflower	>0.5	>0.5	>0.5
Chilli	2.5	>0.5	>0.5

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RESPONSE OF BLACKGRAM (*PHASEOLUS MUNGO*) TO LEVELS OF PHOSPHORUS AND PHOSPHATE SOLUBILIZING BACTERIA

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ABSTRACT

A field experiment on blackgram comprising of four levels of phosphorus with and without phosphate solubilizing bacteria (PSB) and farm yard manure (FYM) was laid out in split plot design with three replications during rainy season of 1997 and 1998 at Regional Agricultural Research Station, IGAU, Raigarh. The soil of the experimental field was sandy loam in texture, slightlyacidic in reaction with low in available nitrogen and phosphorus and medium in available potassium. The results revealed that yield attributes and yield were significantly influenced with the phosphorus levels, PSB and FYM. Application of 60 kg P_2O_5/ha significantly increased the number of pods/plant, 100 seed weight and seed yield of black gram over 30 kg P_2O_5/ha and control but found at par with 30 kg P_2O_5/ha for seed/pod during both the yers. On the mean basis 60 kg P_2O_5/ha produced 10.4 per cent and 69.3 per cent higher yield over 30 kg P_2O_5/ha and control, respectively. Phosphate solubilizing bacteria and FYM resulted in significantly higher length of pod, pods/plant and seeds/pod during 1997, whereas 100 seed weight and seed yield were increased appreciably during both the years. An increasing trend in harvest index was noticed with increasing levels of phosphorus and application of PSB and FYM.

Key words : Blackgram, phosphorus, phosphate soliblising bacteria (PSB).

Blackgram (*Phaseolus mungo*) is one of the important pulse crops grown extensively under rainfed condition in eastern Chhattisgarh. Being a leguminous crop it requires a large amount of phosphorus as compared to other macronutrients. Major portion of applied phosphorus is fixed in the soil in the form of organo-phosphates and becomes unavailable to the plants. The availability of applied phosphorus can be increased by soil micro-organisms which produce organic acids. Phosphate solubilizing bacteria (PSB) are reported to increase the yield of legumes by mobilizing the unavailable P in soil and make it available to the crop (Ahmad and Jha, 1982; Sarawgi *et al.*, 1998). The information on the optimum dose of phosphorus and use of PSB on blackgram is meager in this region, therefore, the present investigation was undertaken.

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MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 1997 and 1998 at Indira Gandhi Agricultural University, Regional Agricultural Research Station, Raigarh. (21.55° N latitude, 83.24° E longitude and 215 m amsl). The soil of the experimental field was sandy loam in texture, slightly acidic in reaction (pH 6.2), low in available nitrogen (195.6 kg/ha) and phosphorus (6.8 kg/ha) and medium in available potassium (215.3 kg/ha). The treatments comprising four levels of phosphorus (0, 30, 60 and 90 kg/ha) with and without phosphate solubilizing bacteria (5 kg/ha) and/or FYM (1 t/ha) were laid out in split plot design with three replications. The seeds of blackgram variety 'TPU-4' were drilled in 30 cm rows using 20 kg seed/ha on July 09 in 1997 and July 16 in 1998. Crop was uniformly fertilized with recommended dose of 30 kg/ha N and K_2O, through urea and muriate of potash and phosphorus was applied as per treatment through single super phosphate before sowing. Seeds were treated with *Rhizobium* culture @ 5 g/kg of seed before sowing. Phosphate solubilizing bacteria was applied mixed with 50 kg soil/ha and FYM was applied @ 1 t/ha. Ten plants from each plot were randomly selected for recording the growth and yield attributes. Grain and straw yields were recorded net plot wise and were subjected to statistical analysis.

RESULTS AND DISCUSSION

Yield attributes

The yield attributes of blackgram were significantly influenced with the application of phosphorus. Application of 60 kg P_2O_5/ha appreciably increased the length of pod over 30 kg P_2O_5/ha and control during 1997, but remained unaffected during 1998. Significant increase in number of pods/plant and 100 seed weight were obtained with the application of 60 kg P_2O_5/ha over 30 kg P_2O_5/ha and control during both the years. However, the increase was non-significant beyond 60 kg P_2O_5/ha. Application of phosphorus @ 30, 60 and 90 kg P_2O_5/ha being at par significantly increased the number of seeds/pod over control during both the years. However, all the phosphorus levels (30, 60 and 90 kg/ha) were similar to each other during, 1997, whereas application of 90 kg P_2O_5/ha being at par with 60 kg P_2O_5/ha produced significantly higher number of seeds/pod over 30 kg P_2O_5/ha during 1998. Significant response of phosphorus application in increasing the yield attributes was also reported by Tomar *et al.* (1993).

Phosphate solubilizing bacteria and FYM significantly improved the length of pod, pods/plant and seeds/pod over control during 1997, whereas these parameters remained unaffected during 1998. However, 100 seed weight was significantly increased with the application of PSB and FYM over control (No PSB/FYM) during both the years. Ahmad and Jha (1982) and Tomar *et al.* (1993) also reported beneficial effect of inoculation with phosphate solubilizing bacteria in legume crops.

Yield

The application of phosphorus markedly increased the seed yield of

Table 1. Yield attributes and yield of blackgram as influenced by phosphorus levels, PSB and FYM

Treatments	Length of pod (cm)		Pods/plant		Seeds/pod		100 seed weight (g)		Seed yield (kg/ha)			Harvest index (%)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	Mean	1997	1998
P_2O_5 (kg/ha)													
0	4.38	4.19	9.3	8.6	5.7	5.2	3.24	2.90	882	320	571	22.9	20.7
30	4.41	4.28	17.0	15.3	6.1	5.9	3.41	3.03	1005	746	876	23.7	21.2
60	4.63	4.48	25.3	19.0	6.3	6.4	2.59	3.20	1107	827	967	24.7	22.8
90	4.60	4.51	26.2	20.2	6.4	6.6	3.56	3.24	1113	842	978	24.3	22.2
S.Em.±	0.03	0.18	0.5	0.8	0.1	0.2	0.04	0.03	41	23	26	–	–
CD (P=0.05)	0.10	NS	1.6	2.8	0.3	0.6	0.14	0.09	142	80	90	–	–
Inoculation													
No PSB/FYM (Control)	4.26	4.20	13.7	14.4	5.3	5.7	2.92	3.03	884	605	745	22.4	21.0
PSB (5 kg/ha)	4.60	4.44	12.0	15.8	6.3	6.1	3.63	3.16	1073	706	890	24.6	21.8
FYM (1 t/ha)	4.66	4.45	22.6	15.7	6.6	6.3	3.73	3.18	1078	740	909	24.7	22.3
S.Em.±	0.03	0.13	0.6	0.5	0.1	0.2	0.04	0.04	93	27	26	–	–
CD (P=0.05)	0.10	NS	1.9	NS	0.3	NS	0.12	0.12	31	81	78	–	–

blackgram over control. During 1997, application of 90 kg P_2O_5/ha being similar to 30 and 60 kg P_2O_5/ha produced higher seed yield over control, but superior over 30 kg P_2O_5/ha significantly improved the seed yield over 30 kg P_2O_5/ha and control. Application of 60 kg P_2O_5/ha produced higher seed yield 10.4% and 69.3% over 30 kg P_2O_5/ha and control, respectively. Phosphorus play important role in root growth, nodule formation and nitrogen fixation in legumes, it also help in translocation of photosynthates to different plant parts which was ultimately reflected in better growth and development of the crop. Higher seed yield due to application of phosphorus may be attributed to increased yield attributing characters. Khandkar and Shinde (1991), Tomar *et al.* (1993) and Singha and Sarma (2001) also reported increase in seed yield due to phosphorus application.

Phosphate solubilizing bacteria and FYM significantly enhanced the seed yield over no PSB or FYM during both the years. On an average 19.5% and 22.0% yield increase was observed with the application of PSB @ 5 kg/ha and FYM @ 1 t/ha, respectively over control. Phosphate solubilizing bacteria are known to mobilize the unavailable P in soil and make it available to the plant. Ahmad and Jha (1982) reported increase in yield of soybean due to inoculation with phosphate solubilizing microganisms *Bacillus megaterium* and *Bacillus cirulans*. Positive response of PSB in increasing the yield of black gram was also reported by Tomar *et al.* (1993). Higher yield of black gram with the application of FYM may be due to the fact that it contains other major and micro nutrients which helped in better availability of nutrients and there by better growth and development of the crop.

An increasing trend of harvest index was observed with gradual increase in levels of phosphorus upto 60 kg P_2O_5/ha. Maximum harvest index was obtained with the application of 60 kg P_2O_5/ha. This may be due to better translocation of photosynthates from source to sink. Khanda *et al.* (1999) also reported increasing trend of harvest index in rice bean with increasing level of phosphorus. Application of PSB and FYM increased the harvest index of blackgram as compared to control.

The interaction effect between levels of phosphorus and inoculation with phosphate solubilizing bacteria and/or FYM for seed yield was found significant during 1997 (Table 2). Seed yield of 1222 kg/ha obtained under 60 kg P_2O_5 with PSB was significantly superior over 90 kg P_2O_5/ha alone and 30 kg P_2O_5/ha alone or in combination with PSB or FYM. However, it was at par to 60 kg P_2O_5/ha with FYM (1080 kg/ha) and 90 kg P_2O_5 with PSB or FYM (1126 and 1170 kg/ha), respectively.

It was concluded that blackgram can be successfully grown with the application 60 kg P_2O_5/ha in combination with PSB @ 5 kg/ha and/or FYM @ 1 t/ha in light textured soils of eastern part of Chhattisgarh.

Table 2. Interaction effect of P x PSB/FYM on seed yield of blackgram during 1997

PSB/FYM	Phosphorus(P_2O_5 kg/ha)				Mean
	0	30	60	90	
No PSB/FYM	526	948	1019	1043	884
PSB (5 kg/ha)	924	1021	1222	1226	1073
FYM (1 t/ha)	1017	1044	1080	1170	1078
Mean	822	1005	1107	1113	1012

	S.Em±	CD (P=0.05)
Phosphorus levels (P)	41	142
PSB/FYM	31	93
Interaction (P × PSB/FYM)	57	172

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PHYSIOLOGICAL AND QUALITATIVE RESPONSES OF IMPROVED SUGARCANE VARIETIES UNDER PLANT CANE IN KONKAN REGION OF MAHARASHTRA

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ABSTRACT

Field experiment was conducted to study the physiological and qualitative responses of promising sugarcane varieties at the Sugarcane Research Scheme, Central Experiment Station, Wakawali during the years of 1991-92 and 1992-93. Two years pooled results revealed that the variety 'Co 8011' produced significantly higher cane yield (93.69 t/ha) and commercial cane sugar (9.58 t/ha) than rest of the varieties except 'Co 7527', 'Co 88011' which were at par with 'Co 8011'. The higher cane yield recorded by 'Co 7527', 'Co 88011' and 'Co 8011' was mainly due to the higher girth and weight/cane attributed by these varieties. Higher cane yield coupled with higher purity and sucrose percentage resulted into the maximum sugar yield in 'Co 801'. This clearly indicated that the higher physiological and qualitative performance of 'Co 8011' under Konkan agroclimatic conditions resulted into the production of maximum cane as well as sugar yield per hectare. The varieties 'Co 7527' and 'Co 88011' were also performed better and found equally good with 'Co 8011'.

Key words : Sugarcane, variety, yield

Selection of genotype better suited for agro-climatic conditions is the most important aspect in crop production. Different varieties show differential yield performance under different agroclimatic conditions. Yield potential of any genotype is resultant of growth and qualitative performance of the variety in particular agroclimatic situations. To increase the yield per unit area and per unit time many high yielding genotypes of sugarcane have been evolved. Sugarcane being a new introduction in Konkan, evaluation of these improved genotypes under agroclimatic conditions of Konkan needs no emphasis. Balasundaram and Bhagyalakshmi (1978) also observed wide variation in yield potential and quality of different varieties under different agroclimatic situations. In view to this, the present investigation was carried out to study the performance of some promising sugarcane varieties for the yield potential and sugar yield under high rainfall conditions of coastal Maharashtra.

MATERIALS AND METHODS

A varietal trial with 17 promising varieties was conducted at Sugarcane Research Scheme, Central Experimental Station, Wakawali during two consistent seasons of 1991-92 and 1992-93. The treatments comprised 17 promising sugarcane varieties viz., 'Com 88121', 'Co 8011', 'Co 88016', 'Co 88017' 'Co 88002', 'Co. 88011', 'Co 88024', 'Co 88025', 'Co 88027', 'Co 88028', 'Co 88029', 'Co 88030', 'Co 88031', 'Co. 88032', 'Co. 88033', 'Co 7219' and 'Co 7527' replicated twice in randomized block design. The net plot size was 3.60 m × 5.00 m. The experimental crop was planted in second week of January in both the years by adopting 90 cm spacing between furrous using 30,000 three eye budded sets/ha by wet method. The soil of the experimental plot was lateritic with 5.80 pH, low in available phosphorus and medium in available potassium and nitrogen content. Sugarcane crop of all the treatments was fertilized with 250 kg N, 125 kg P_2O_5 and and 125 kg K_2O/ha. The 10% nitrogen and full dose of P_2O_5 and K_2O was applied at the time of planting. Out of remaining does of nitrogen 40%, 10% and 40% nitrogen was given at an interval of 6 weeks from each preceding dose. Need based plant protection and weed control measures were followed. One earthing was given in the month of June after the commencement of the monsoon rain. Harvesting of the crop was done in first week of February each year.

The observations in respect of growth and yield attributes, yield, quality characters of different varieties were recorded. The data in respect of two plant crops were pooled.

RESULTS AND DISCUSSION

Growth studies

Height of millable cane (cm)

Amongst the different varieties under study, 'Co 88031' produced the tallest canes of 248.33 cm height (Table 1). This height was significantly higher than the height of the cane recorded by all other varieties except 'Co. 88031', 'Co 88028', 'Co 8011' and 'Co 88031' which produced statistically qual height.

Girth of cane (cm)

As far as girth of cane was concerned, sugarcane variety 'Co 88011' superceded all the varieties by producing the thickest cane of 9.74 cm girth (Table 1). The girth produced by 'Co 88011' was significantly more than all other varieties except 'COM 88121', 'Co 8011', 'Co 88028', 'Co 88029', 'Co 88029' and 'Co 7527' which were on par with the former variety in respect to girth per cane. Sugarcane variety 'Co 88031' recorded the minimum girth of 7.94 cm.

Weight per cane (kg)

The sugarcane variety 'Co 7527' recorded the maximum weight per cane i.e. 1.42 kg, which was on par with weight per cane recorded by 'Co 8011', 'Co 88017', 'Co 88011' and 'Co 88028' and significantly higher over rest of the varieties. The lowest weight per cane was observed in variety 'Co 7219'.

Millable cane populations

The date pertaining to millable can population presented in Table 1, revealed that, the millable cane population was highest in the variety 'Co 7219' (86,203/ha) followed by 'Co 88027' (83,333/ ha) and 'Co 88011' (82,036/ ha). The minimum population of millable canes was observed in 'Co 88031'.

Quality studies

Brix percent

There was significant variation in the

Table 1. Growth characters, juice quality, cane and sugar yield (Two years pooled data)

Varieties	Millable cane population/ha	Mean height per cane (cm)	Girth per cane (cm)	Weight per cane (kg)	Brix (%)	Sucrose (%)	Purity (%)	Cane yield (t/ha)	CCS (t/ha)
'COM 88121'	75687	200.00	9.30	1.06	18.83	16.04	85.04	78.37	7.35
'Co 8011'	79258	237.50	9.55	1.38	18.26	16.46	90.29	93.69	9.58
'Co 88016'	68147	225.83	8.02	1.05	19.25	15.98	83.22	63.71	6.00
'Co 88017'	72778	222.50	9.08	1.23	20.23	16.76	84.14	72.67	7.08
'Co 88002'	80461	220.83	8.49	0.99	19.61	17.28	88.46	71.77	7.12
'Co 88011'	82036	240.83	9.74	1.37	18.16	15.65	86.36	85.79	8.73
'Co 88024'	72483	215.00	8.63	1.10	18.56	15.57	83.90	64.41	6.09
'Co 88025'	64360	216.67	9.05	1.18	18.29	16.51	90.13	55.78	5.55
'Co 88027'	83333	224.16	9.03	1.12	18.17	15.12	83.59	73.45	8.37
'Co 88028'	73797	239.16	9.40	1.26	19.77	15.15	76.57	76.31	6.78
'Co 88029'	73055	204.16	9.48	1.11	18.07	14.84	82.53	65.17	6.02
'Co 88030'	70163	220.83	9.05	1.20	18.36	16.12	87.89	76.73	7.10
'Co 88031'	58887	248.33	7.94	1.04	18.91	16.44	87.04	56.64	5.66
'Co 88032'	77777	218.33	9.04	1.11	18.84	15.80	84.08	69.97	7.11
'Co 88033'	78611	212.50	9.07	1.09	17.57	15.27	86.70	74.05	7.64
'Co 7219'	86203	222.50	7.96	0.94	18.53	16.11	87.06	66.85	6.30
'Co. 7527'	70925	235.00	9.39	1.42	18.32	16.13	87.44	8751	9.02
S.Em.±	-	7.44	0.19	0.07	0.39	0.35	1.76	4.63	0.78
CD at 5%	-	20.63	0.54	0.20	1.10	NS	4.98	13.87	2.20

brix percentage due to different varieties under study. 'Co. 88017' recorded the maximum brix percentage (20.23%) which was significantly higher than all other varieties except 'Co 88002' and 'Co 88016'. The differences in brix percentage in 'Co 88017', 'Co 88002' and 'Co 88016' were nonsignificant.

Sucrose percent

The sucrose percentage was not influenced significantly due to different varieties under study. The maximum sucrose percentage was observed in 'Co 88002' whereas, minimum sucrose percentage was recorded in 'Co 88027'.

Purity percent

Sugarcane variety 'Co 8011' recorded significantly higher purity percentage than all other varieties except 'Co 88002', 'Co 88011', 'Co 88025', 'Co 88030', 'Co 88031', 'Co 88033', 'Co 7219' and 'Co 7527' which were on par with 'Co 88011'.

Commercial cane sugar

Different varieties showed significant variation in the production of commercial cane sugar. Highest sugar yield of 9.58 t/ha was recorded by the variety 'Co 8011' which was significantly higher than all other varieties under study except 'Co 7527', 'Co 88011', 'Co 88027' and 'Co 88033'. 'Co 8011', 'Co 7527', 'Co 88011', 'Co 88027' and 'Co 88033' were found equally good as far as sugar production was concerned.

Cane yield (t/ha)

Different varieties showed significant variation in cane yield per hectare. The variety 'Co 8011' produced the maximum cane yield of 93.69 t/ha which was on par with the yield produced by 'Co 7527' and 'Co 88011' and significantly higher over rest of the varieties. The highest cane yield in the 'Co 8011', 'Co 7527' and 'Co 88011' was attributed to the higher girth and weight per cane of these varieties.

It can be concluded that the physiological qualitative and yield performance of 'Co 8011', 'Co 88011' and 'Co 7527' was better under agroclimatic conditions of Konkan and hence these verities are suitable for cultivation under high rainfall condition of Konkan region of Maharashtra.

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EFFECT OF PLANTING GEOMETRY, NITROGEN AND SULPHUR ON SEED QUALITY OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

An experiment conducted on a sandy loam soil of A.R.S. Sriganganagar to study the effect of different planting geometries (60×30 cm, 50×30 cm, 40×30 cm and 30×30 cm), levels of nitrogen (40, 80 and 120 kg/ha) and sulphur (0, 25 and 50 kg/ha) on seed quality of sunflower (*Helianthus annus* L.). The studies showed that wider planting geometry 60×30 cm recorded significantly higher oil content. Whereas, medium planting geometry 40×30 cm recorded significantly higher oil yield. The application of 80 kg N/ha significantly increased the oil yield as compared to 40 kg N/ha. Whereas, the protein content in seed increased upto 120 kg N/ha. Significant increase in seed protein and oil content was observed upto 25 kg S/ha, whereas, oil yield/ha increased significantly upto 50 kg S/ha, The optimum combined level of N and S for oil yield was found 107 kg N and 49.5 kg S/ha.

Key words : Sunflower, planting gometry, nitrogen, sulphur, seed quality.

The oil and protein content of sunflower is greatly influenced by plant population, nitrogen and sulphur application. Different workers have reported that sulphur fertilization improves both the quantity and quality of oilseeds. Sulphur play an important role in the synthesis of S-containing amino acids, which are responsible for increasing oil concentration in oil seeds (Tandon, 1986). The sulphur fertilization and its availability in the soil also governs the absorption of other available nutrients, specially nitrogen by the plants. This study was undertaken to find out effect of plant population, nitrogen and sulphur on quality of seed in sunflower.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Station, Sriganganagar during spring season of 1992 and 1993 on a sandy loam soil. The soil had pH 8.3, 119.0 kg, available N, 38.5 kg, available P_2O_5, 363.0 kg/ha available K_2O and 8.9 ppm available SO_4-S. The treatments consisted of four planting geometries (60×30 cm, 50×30 cm, 40×30 cm and 30×30 cm), three levels of nitrogen (40, 80 and 120 kg/ha) and three levels sulphur (0, 25 and 50 kg/ha). The experiment was laid out in split plot design with 3 replications taking planting geometry as the main plot treatment. The combinations of nitrogen and sulphur were taken as sub plot treatment.

A uniform dose of 50 kg P_2O_5/ha through DAP and half of the dose of nitrogen as per treatment through urea after adjusting the quantity of N supplied by DAP, was drilled in lines as per planting geometry before sowing as basal dose. The remaining half dose of nitrogen was top dressed through urea at first irrigation. Sulphur as per treatment was incorporated in soil through elemental sulphur 21 days before sowing.

The seeds of sunflower hybrid 'MSFH-8' were dibbled in rows 30, 40, 50 and 60 cm apart, keeping plant-to-plant spacing of 30 cm as per treatments. Sowing was done on 8 February and 3 February in 1992 and 1993, respectively. Total three irrigations were given to the crop in both the years of experimentation.

The protein content (%) was estimated by multiplying the percent concentration of nitrogen in the seed with 6.25 (Walinga *et al.*, 1989). Oil content (%) in sunflower was estimated by Soxhlet apparatus using petroleum ether (60-80°C) as an extractant (A.O.A.C. 1960). The oil yield (kg/ha) was calculated by multiplying the percent oil content with a respective seed yield. The oil protein ratio was calculated by dividing oil content with protein content.

Results and Discussion

The percent oil content in sunflower seed was significantly higher under lower plant population ($P_{60\times30}$) as compared to higher plant population ($P_{40\times30}$ and $P_{30\times30}$). Whereas, oil yield was significantly higher under medium plant populations ($P_{50\times30}$ and $P_{40\times30}$) as compared to thin ($P_{60\times30}$) and dense ($P_{30\times30}$) populations (Table 1). This might be because of the fact that in low plant population plots the plant growth improved in terms of height and dry matter and resulted in better yield attributes viz. head diameter, seeds per head, weight of seeds per head and test weight of seeds, which might have reflected in contributing towards higher oil content in seeds. However, the total oil yield per unit area was more under medium plant population ($P_{50\times30}$ and $P_{40\times30}$) owing to higher seed yield under these treatments as the increase in percent oil content under $P_{60\times30}$ was compensated by the increase in seed yield under $P_{40\times30}$. These findings are in close conformity with those of Rao and Rao (1976) who reported that higher plant population lowered the oil content of sunflower. Similar results have also been reported by Samui et al. (1987).

The significant increase in seed protein content with the increase in the level of applied nitrogen and in oil yield upto 80 kg N/ha was observed. Whereas, the oil protein ratio decreased significantly upto 80 kg N/ha (Table 1). The protein content of seed being essentially a manifestation of its N content seems the result of higher N content of seed under N fertilization. The increase in oil yield upto 80 kg N/ha was probably due to increased seed yield being the function of oil content and seed yield. Further the reduction in oil protein ratio was probably due to insignificant effect on oil content and significant increase in seed

Table 1. Effect of planting geometry, nitrogen and sulphur on protein content, oil content, oil yield and oil protein ratio (Pooled data of 2 years)

Treatment	Protein content (%)	Oil content (%)	Oil yield (kg/ha)	Oil : Protein ratio
Planting geometry (cm)				
$P_{60\times30}$	18.01	34.9	739.2	1.934
$P_{50\times30}$	17.97	34.4	778.9	1.918
$P_{40\times30}$	17.98	33.8	776.1	1.880
$P_{30\times30}$	18.05	33.0	619.2	1.830
S.Em±	0.12	0.24	10	0.021
CD at 5%	NS	0.75	31	NS
Nitrogen (kg N/ha)				
N_{40}	17.39	34.0	666.3	1.949
N_{80}	18.11	34.1	754.1	1.882
N_{120}	18.50	34.1	764.7	1.841
SEm±	0.10	0.18	8	1.017
CD at 5%	0.28	NS	23	0.048
Sulphur (kg S/ha)				
S_0	17.60	33.5	652.2	1.902
S_{25}	18.10	34.1	749.5	1.882
S_{50}	18.30	34.5	783.4	1.887
SEm.±	0.10	0.18	8	0.017
CD at 5%	0.28	0.49	23	NS

protein content due to N fertilization which reduced the oil protein ratio significantly. The increase in protein content and nonsignificant effect on sunflower seed oil content due to N fertilization have also been reported by Panikar (1974) and Tripathi (1977).

Significant increase in seed protein and oil content was observed upto 25 kg S/ha whereas oil yield/ha increased significantly upto 50 kg S/ha. This might be due to fact that since protein content in seed is the function of its N content, the significant improvement in N content of seed due to application of sulphur brought significant improvement in protein content of this parameter. Further sulphur being an integral part of S containing amino acids viz. cystein, cystine and methionine, also improved protein as well as oil synthesis in seeds. Improvement in protein and oil content of sunflower seed due to sulphur application have also been reported by Gangadhara *et al.* (1990) and Tamak *et al.*, (1997). Similar results in Indian rape have been reported by Mohapatra and Jee (1992).

Interaction effect of planting geometry and nitrogen

Data regarding combined effect of planting geometry and nitrogen on pooled mean oil yield of sunflower presented in (Table 2) reveal that the spacings of (50×30 cm and 40 × 30 cm) in combination with nitrogen level N_{80} and N_{120} were at par significantly better over all other combinations of nitrogen and spacings.

Combined effect of N and S

The oil yield as a function of combined effect of nitrogen and sulphur (N × S) fertilization was worked out through production function of the type $Y = b_0 + B_1N + b_2S + b_3N^2 + b_4S^2 + b_5NS$). The production function showed very high value of coefficients of determination (R^2 = 0.99995) and multiple correlation (R = 0.99998) with a pooled mean optimum level of N (107 kg/ha) and S (49.5 kg/ha) for getting an optimum oil yield of 833.6 kg/ha (Table 3).

Table 3. Oil yield (Y) as a function of combined effect of nitrogen and sulphru (N×S) fertilization – A production function $Y = b_0+b_1N + b_2S+b_3N^2+b_4S^2+b_5NS$

Study parameters	1992	1993	Pooled
(1) Partial regression coefficients			
b_0	487.014	416.496	451.755
b_1	53.3077**	41.9045**	47.6059**
b_2	43.2833**	34.4889**	40.8861**
b_3	-2.7318**	-2.1024**	-2.4171**
b_4	-5.2800**	-4.8822**	-5.0811**
b_5	1.4479**	1.2438**	1.3458**
(2) Coefficient of			
i. Determination (R^2)	0.999956**	0.999990**	0.999975**
ii. Multiple correlation (R)	0.999978**	0.999995**	0.999987**
(3) Optimum combined levels of nutrients (NS_{opt})			
N opt (kg/ha)	106.5	107.9	107.1
S opt (kg/ha)	50.8	48.0	49.5
(4) Oil yield at NSopt (kg/ha)	906.9	760.6	833.6
(5) Response to NSopt over absolute control (kg/ha)	419.9	344.1	381.8

Note : The partial regression coefficients (b_1 to b_5) are based on N and S units of 10 kg each

Table 2. Interaction effect of planting geometry and nitrogen on pooled mean oil yield (kg/ha) of sunflower

Treatments	$P_{60\times30}$	$P_{50\times30}$	$P_{40\times30}$	$P_{30\times30}$
N_{40}	705.7	733.9	710.9	514.6
N_{80}	757.7	801.0	803.2	654.5
N_{120}	754.2	801.6	814.1	688.6
		SEm±	CD at 5%	
N at same level of P		16.3	45.6	
P at same or different levels of N		16.6	48.2	

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HYBRID VIGOUR IN BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT

The exploitation of hybrid vigour in brinjal using a diallel cross involving 10 parents (excluding reciprocals) were studied for manifestation of better and mid parent heterosis for fruit yield per plant and eleven other yield attributing triats. All the 45 hybrids showed positive and significant heterosis over better and mid parents for fruit yield per plant. The better parents and mid parents heterosis ranged from 21.06 to 166.03% and from 23.33 to 197.81%, respectively. Significant values of heterosis over better parent as well as mid parent were also observed for other attributes, indicating their contribution to the heterosis for fruit yield. The performance of the best five heterotic hybrids observed in the present study were viz., P7×P8, P8×P10, P6×P10, P6×P8 and P5×P6, where as for early flowering and fruiting P1×P4 hybrid has shown the best performance.

Key words : Brinjal, hyrid vigour, manifestation.

Recent exploitation of hybrid vigour in vegetable crops is considered to be one of the outstanding achievements in vegetable breeding. To know the potentiality of hybrids in a particular crop, the magnitude and direction of heterosis is of paramount importance. Heterosis response largely depends upon the genetic divergence among parents involved in a particular study. In India, wide genetic variability in brinjal was reported by several workers. Very meager work has been done especially in Southern Rajasthan on brinjal which is one of the major vegetable crop of this state. In the present study, an attempt has been made to gather information on the extent of heterosis in a diallel cross to produce promising hybrids/pure lines in brinjal.

MATERIALS AND METHODS

Ten diverse brinjal parents namely, 'Pusa Ankur' (P1), 'Arka Nidhi' (P2), 'Arka Keshav' (P3), 'IC-112358' (P4), 'IC-90984' (P5), 'Pusa Uttam' (P6), 'Pusa Purple Cluster' (PPC) (P7), 'Udaipur Local' (P8), 'Pusa Upkar' (P9) and 'Pusa Bhairav' (P10) were chosen on the basis of their phenotypic performance and their diverse variation in yield and its contributing traits. The parents alongwith their F_1's without reciprocals were grown in a randomised block design with three replications. The spacing 75×60 cm was adopted in rows of 7.20 m length.

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Recommended cultural practices and plant protection operations were followed to raise a good crop. Following observations were recorded on five randomly selected plants from each replication, viz., days to first flowering, days to 75 per cent flowering, days to first fruit harvest, leaf area (cm), plant height (cm), plant spread (cm), number of fruit clusters per plant, fruit length (cm), fruit width (cm), number of fruits per plant, average fruit weight (g), average fruit yield per plant (kg). Heterosis was calculated over mid, better and best (top) parents, respectively. In the present study, the economic heterosis for fruit yield as well as other yield attributing traits were calculated over the standard parent i.e. 'Udaipur Local' (P8), a local and commonly grown variety in southern Rajasthan having spines on the fruit calyx.

RESULTS AND DISCUSSION

Differences among the parents and F_1 hybrids were substantial for different characters studied. The estimates of heterosis over mid, better and standard parent for different characters were calculated. The range of parents and F_1's average performance of heterosis over all crosses and over heterotic crosses, number of heterotic crosses, range of heterosis over better parents, best heterotic F_1's, best performing F_1 and the top parent value are presented in Table 1. In general, wide range and higher means were recorded in F_1's except for the days to first flowering, days to 75% flowering and days to first fruit harvest where negative values were considered. Out of the 45 F_1 hybrids, as many as 10 and 39 were better than their better parents and standard parent, respectively in respect of days to first flowering and days to 75 per cent flowering, 22 in days to first fruit harvest, 26 in leaf area, 28 in plant height, 12 for plant spread, 6 for number of fruit clusters per plant, 12 in fruit length, 3 in fruit width, 36 for number of fruits per plant, 12 in average fruit weight and all the 45 F_1 hybrids in fruit yield per plant.

In all the characters, the best performing F1 hybrid was better than the top parent except days to first flowering, days to 75 per cent flowering and days to first fruit harvest, where lower values were desirable and considered, which had highest value for the particular character.

In case of days to first flowering and days to 75 per cent flowering 10 cross combinations showed negative and significant heterosis over better parents, while 21 and 20 cross combinations exhibited negative and significant heterosis over their respective mid parental value for these two characters.

Wide range of heterosis over better parent was recorded, ranged from -2.45 to -18.01 and -2.47 to -1.61 for these two characters, respectively. The hybrid 'P1×P4' showed maximum heterosis for both the characters. This hybrid is also the best performer in respect of these two characters. Presence of heterosis for early flowering and fruiting in brinjal has also been reported by Nagai and Kida (1926).

The heterosis for leaf area over better parent ranged from 6.14-61.69%. Heterosis was significant and positive in 26 crosses and 39 crosses over the better parent and mid parents, respectively. The size of leaf

Table 1. Range and mean values of parents and F1 hybrids and heterosis

Range, mean and heterosis	Days to first flowering	Days to 75% flowering	Days to first fruit harvest	Leaf area (cm^2)	Plant height (cm)	Plant spread (cm^2)	Fruit clusters/ plant	Fruit length (cm)	Fruit width (cm)	Number of fruits/ plant	Av. fruit weight (g)	Av. fruit yield/ plant (kg)
Parents range	67.73-74.07	74.67-82.00	79.40-92.73	127.24-229-78	65.47-87.67	67.99-103.40	13.73-17.80	8.77-24.30	2.66-7.57	28.67-78.07	47.57-170.67	2.61-5.11
Hybrid	55.53-72.87	66.00-81.33	69.07-88.60	166.82-270.34	76.87-108.13	62.97-114	12.73-28.40	8.90-25.20	2.53-7.49	33.33-127.40	52.00-193.00	4.68-13.13
Parents mean	71.20	79.80	87.64	182.95	79.32	86.21	15.53	14.18	4.99	41.13	96.23	3.84
Hybrids	69.39	78.21	84.36	219.36	90.89	93.30	17.79	15.67	4.87	69.27	102.86	7.53
Grand mean	69.72	78.50	85.01	212.74	88.80	92.01	5.38	15.40	4.89	64.16	101.66	6.86
C.V. %	1.35	1.42	4.28	2.68	3.35	3.40	15.38	3.52	3.70	6.13	5.15	5.53
Top Parent	(P1) 67.73	(P1) 74.67	(P1) 79.40	(P9) 229.78	(P4) 87.67	(P4) 103.40	(P7) 17.80	(P3) 24.30	(P6) 7.57	(P7) 78.07	(P9) 170.67	(P9) 5.11
Best Performing F1	(P1×P4) 55.53	(P1×P4) 66.00	(P1×P4) 69.07	(P2×P3) 270.34	(P7×P8) 108.13	(P7×P8) 114.00	(P7×P8) 28.40	(P2×P3) 25.20	(P6×P9) 7.49	(P2×P7) 127.40	(P6×P9) 193.00	(P7×P8) 13.13
Average Heterosis (%)	-19.75	-14.84	-16.45	37.60	43.48	46.12	219.00	11.09	0.79	111.98	26.56	197.81
Number of heterotic crosses	21,10,39	20,10,39	37,22,44	39,26,31	39,28,45	28,12,35	13,6,1	29,12,45	8,3,11	44,36,45	26,12,14	45,45,45
Range of hecterotic (%) over B.P.	-2.45-(-)18.01	-2.47-(-)-11.61	-2.48-13.01	6.14-61.69	6.08-42.53	8.43-33.00	10.68-59.55	3.70-34.97	11.24-27.65	12.64-116.45	9.40-27.80	21.06-157.87
Best heterotic F1 (%) Over B.P.	(P1×P4) -18.01	(P1×P4) -11.61	(P1×P4) -13.01	(P4×P7) 61.69	(P7×P8) 42.53	(P7×P8) 29.45	(P7×P8) 59.55	(P5×P7) 34.97	(P1×P8) 16.54	(P3×P10) 116.45	(P4×P8) 18.23	(P7×P8) 157.87

Parents and crosses are shown in brackets
BP = Better parent

in brinjal is an important attribute. The total leaf area per plant in a particular range contributed towards yield character. Reflection on yield beyond this range of total leaf area indicated declining trend. This is in agreement with the findings of Choudhary and Mishra (1988).

Only 28 and 12 out of 45 hybrids showed significant and positive heterosis over better parent in plant height and plant spread, respectively, while 39 and 28 hybrids have shown significant and positive heterotic effect over mild parental value for the same attributes.

It was observed that plant height and spread governed the yield potential of plant because F1 hybrids depicted tallness over their taller parent and in the taller stages of growth, hybrids depicted better vegetative vigour and thus the increased number of primary branches, increased number of fruits per plant. Similar results have also shown by Thakur *et al.* (1966). Maximum heterosis for fruit clusters per plant (59.55% recorded in cross P7 × P8.

Out of 45 hybrids 12 and 3 cross combinations exhibited significant and positive heterosis over better parent for fruit length and fruit width, respectively.

Maximum heterosis 34.97% was observed in hybrid P5 × P7 for fruit length. Similar trend of results have also been obtained by Dixit and Gautam (1987).

The cross combination P6 × P9 was found to be best performing hybrid for fruit width and average fruit weight. In brinjal fruit width and fruit weight are directly related to the fruit yield. The similar findings have also been reported by Singh and Krishna Prasad (1995).

In case of fruit weight the parent P9 has recorded the maximum mean fruit weight (170.67 g), whereas the best performing F1 hybrid P6 × P9 has recorded (193.00 g).

Yield per plant ranged from 2.61 kg. (P4) to 5.11 kg. (P9) in case of parents and from 4.68 kg (P2×P8) to 13.13 kg (P7×P8) for hybrids. All the 45 hybrids exhibited significant and positive heterosis for fruit yield per plant. The highest magnitudes of heterosis for yield per plant over mid (197.81%), better (157.87%) and standard (252.38%) parent indicating the great possibility of heterosis breeding in brinjal. The range of heterosis was from 21.06 to 157.87% over the better parents and from 23.33 to 197.81% when compared to the corresponding mid parents and from 23.33 to 197.81% when compared to the corresponding mid parents. The cross P7 × P8 showed highest magnitude of heterosis for fruit yield and other economic characters. Chadha and Sidhu (1982) noted that the increased yield over their respective better parents in heterotic hybrids ranging from 6.50 to 142.19 per cent.

It can be concluded that heterosis for fruit yield per plant, number of fruits and fruit clusters, fruit width, days to harvest and plant height and spread would, to a large extent, decide about the magnitude of heterosis for average fruit yield potentiality. Further, it also indicates, the heterosis for yield might be through individual yield components or alternatively due to multiplicative effects of partial dominance of component characters. P7 and P8 stood out as most divergent parents among the parental lines as one of them is involved in most of the crosses for highest heterotic effects. However, in the present investigation, considerable heterosis was recorded in most of the crosses.

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CROP COEFFICIENTS OF PEARLMILLET (*PENNISETUM GLAUCUM*) UNDER RAINFED CONDITION

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ABSTRACT

Field experiment was conducted under rainfed condition to study the crop coefficient of pearlmillet at different phenophases during the *kharif* season of the years 1994 to 1999. The ratio of crop evapotranspiration to pan evaporation from sowing to harvest of the crop was computed for four different phenophases. The values of crop evapotranspiration ranged between 123.7 to 240.5 mm in all the growing seasons. The evapotranspiration values were lower than pan evaporation values in all the growing seasons. The higher crop coefficient values (0.59 to 1.23) were observed during crop season, 1995 and lower (0.39 to 0.84) in the year, 1999. The values of crop coefficients as well as ratios of evapotranspiration to pan evaporation were higher during the flag leaf and milking phase which were the critical phenophases of pearlmillet crop for water requirement.

Key words : Rainfed, crop coefficient, evapotranspiration, pan evaporation, phenophases.

The nature of rainfall and higher atmospheric demand of water are the major climatic constraints for better production of the crop. Evaporation from soil and plant surfaces commonly known, as evapotranspiration is a primary component of the energy exchange function and determines the production potential of crop species and the distribution of natural vegetation. The pearlmillet crop is mostly grown in rainfed condition. It has a specific water use pattern throughout the growing season. This is largely determined by length the growing season and atmospheric evaporative demand (Greacen and Hignett, 1976).

A great need to improve water management requires a good quantitative estimate of the consumption of water of evapotranspiration. A little information is available on crop coefficient of pearlmillet for different growth phenophases under rainfed condition. A study was, therefore, undertaken to find out the crop coefficient (Kc) values of pearlmillet during the different phenophases under rainfed condition.

MATERIALS AND METHODS

The study utilized data for the years from 1994 to 1999 of pearlmillet (HHB 67) at Hisar station (29°10'N, 75°46'E and height above MSL 215.2m) in Haryana. The evapotranspiration of crop (ET) was measured using two Weighing Volumetric

Lysimeter installed in the crop field at CCS HAU Research Farm and maintained by India Meteorological Department under rainfed condition. The evaporation (EP) values were recorded from Class A Open Pan Evaporimeter, while the potential evapotranspiration (PET) was calculated by modified Penman's method (Dorrenbos and Pruitt, 1977).

The values of crop coefficient (Kc) were computed using the formula as below

$$Kc = \frac{ET(crop)}{PET}$$

Where ET (crop) is consumptive use of moisture (mm/day) measured by Lysimeter and PET is reference crop evapotranspiration by modified Penman's method.

The ratio of evapotranspiration to evaporation (ET/EP) from sowing to harvest of the pearlmillet crop was computed for four phenophases i.e., emergence, flag leaf, milking and maturity phase.

RESULTS AND DISCUSSION

The total growing season evapotranspiration (ET), evaporation (EP) and potential evapotranspiration (PET) during different *kharif* seasons are given in Table 1. Variability in ET values was observed in different growing seasons. This was probably due to variations inherent in monsoon rainfall. Evapotranspiration values ranged between 123.7 to 240.5 mm among all seasons. The ET values were lower than pan evaporation values in all the years due to low transpiration rate. PET values also showed variability among the different seasons. Hundal and Sandhu (1989) reported that total seasonal ET of maize crop varied between 332 to 352 mm. The ET and EP ratios at various phenological stages of the crop are given in Table 2. The ET/EP ratios were lower during initial phenophases and attained maximum at milking stage and then decreased towards maturity. This was mainly because of lower crop growth during initial stages and peak growth rates during milking phase. The crop growth rate might decrease as crop approached maturity phase because of senescence of the leaves. The mean values of ET/EP ranged between 0.36 and 0.73 in all growing seasons. Similar results were reported by Jadhav *et al.* (1997) for gram crop and Tripathi *et al.* (1989) for wheat crop.

The crop coefficient (Kc) values at different phenophases were given in Table 3. The highest Kc values were observed during the year 1995 and lowest during *kharif* season, 1999. The Kc values also showed similar trend as that of ET/EP rates during the whole growing season in all the years. The higher values during flag leaf and milking phase indicated that these are the critical stages for the water requirement in pearlmillet. Similar results were also reported by Das *et al.* (1995) for *kharif* rice crop.

From the study, it was concluded that initially demand of water of pearlmillet crop was low, it reached maximum during flag leaf and milking phase and then decreased towards crop maturity. Therefore, flag leaf to milking phase is the most critical period for water requirement by pearlmillet crop.

Table 1. Total crop evapotranspiration (ET), pan evaporation (EP) and potential evapotranspiration (PET) during different growing seasons of pearlmillet crop

Growing Seasons	Evapotranspiration (mm)	Pan-evaporation (mm)	Potential evapotranspiration (mm)
1995	229.4	278.0	255.3
1996	163.0	247.3	249.3
1997	154.1	303.4	177.3
1998	240.5	410.4	309.8
1999	123.7	440.9	213.8

Table 2. Evapotranspiration and pan evaporation ratios (ET/EP) of pearlmillet crop during different growing seasons

Phenophases	Growing seasons					
	1995	1996	1997	1998	1999	Mean
Emergence	0.55	0.32	0.57	0.31	0.22	0.39
Flag leaf	0.82	0.41	0.45	0.44	0.31	0.49
Milking	1.01	0.59	0.71	0.93	0.39	0.73
Maturity	0.55	0.46	0.29	0.38	0.12	0.36

Table 3. Crop coefficient (Kc) of pearlmillet crop at different phenophases during different growing seasons

Phenophases	Growing seasons					
	1995	1996	1997	1998	1999	Mean
Emergence	0.59	0.34	0.53	0.42	0.39	0.45
Flag leaf	1.11	0.65	0.87	0.85	0.62	0.82
Milking	1.23	0.96	1.09	0.96	0.84	1.02
Maturity	0.40	0.45	0.59	0.44	0.25	0.43

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SELECTION INDICES IN SALINITY TOLERANT WHEAT GERMPLASM

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ABSTRACT

Using 52 salinity tolerant genotypes of wheat, selection indices for grain yield were constructed. All possible combinations based on five characters viz., days to flowering, tillers per plant, spikelets per ear, grains per ear and 1000-grain weight were judged. Efficiency of indices over direct selection for grain ranged from 0.48 to 2.92. Selection index based on individual characters namely, tillers per plant and 1000-grain weight alone expressed 1.79 and 1.62 times, respectively more efficiency over direct selection for grain yield. Progressive increase in the relative efficiency based on two, three, four or five characters combination over direct selection was observed. Maximum advance (20.09) was expected while including all the five yield component characters, however, four characters combination including tillers per plant, spikelets per ear, grains per ear and 1000-grain weight was quite comparable (19.61) suggesting important role of these four characters while making selections specifically in saline environment.

Key words : Selection indices, grain yield, genetic advance, relative efficiency, wheat, salinity..

Soil salinity is a major environmental factor causing decreased yield of crops grown in irrigated systems in semi-arid and arid zones (Downton, 1984). Breeding and selection techniques can be used to achieve increases in plant salt tolerance (Epstein *et al.* 1980). Most plant breeding programmes involve selection of high yielding genotypes. But selection of the basis of yield *per se*, is often not effective owing to the low heritability of the character. Smith (1936) suggested the use of selection index which provides a means for making use of correlated characters for higher efficiency of selection for yield. Several studies on selection indices in wheat (Paroda and Joshi, 1970; Branlard *et al.*, 1992; Nirala and Jha, 1997) have been made from normal environment only. Such relations may get altered in changed micro-climatic conditions e.g., soil salinity. A very few or none of the studies have been made under sub-normal or suppressive soils. In the present investigation, an attempt has been made to find out suitable selection indices in saline environment keeping in view the components of yield and their inter-relationships.

MATERIALS AND METHODS

The material consisted of 52 genotypes of wheat (*Triticum aestivum* L. *em.* Thell) including Kharchia 65, Raj 3077, KRL 1-4, WH 157, LOK 1, Job 666, Job 673 and HP 1529 having wide diversity for salinity tolerance. These genotypes were evaluated in randomized block design with three replications during *rabi* 1998-99 at S.K.N. College of Agriculture, Agricultural Farm, Jobner under saline sodic (pH 8.9, ECe 8.8 ds m^{-1}) soil. Each plot consisted of 2.0 m long single row plot, 30 cm apart with 10 cm plant to plant distance. Data on five competitive plants from each plot were used to record observations on days to flower (X_1), tillers per plant (X_2), spikelets per ear (X_3), grains per ear (X_4), 1000-grain weight (X_5) and grain yield per plant. Selection indices for yield were constructed following Robinson *et al.* (1951). The expected genetic advance from different selection indices at 5% selection intensity and relative efficiency of each function over direct selection for grain yield per plant was computed.

RESULTS AND DISCUSSION

The selection indices, expected genetic advance (E.G.A.) based on discriminant function and their relative efficiency (R.E.) over straight selection for grain yield per plant are presented in Table 1. The expected genetic advance in grain yield at 5% selection intensity ranged from 2.48 to 16.86 as compared with 8.67 from direct selection for yield *per se*. Selection based on tillers per plant alone resulted in an advance of 13.44 giving a relative efficiency of 1.79 over direct selection. The character tillers per plant expressed itself as most important constituent when present in other indices also. Another character, 1000-grain weight also showed 1.62 times more efficiency over direct selection. A progressive increase in the relative efficiency based on two, three, four, or five characters combination over direct selection was observed. Robinson *et al.* (1951) also observed in corn, a progressive increase in the efficiency of selection indices with the inclusion of every additional character in the index formula. Paroda and Joshi (1970) also found maximum expected gain when all the five characters were included in the discriminant function. However, they opined that more attention should be given to 1000-grain weight and grain yield per plant in that order. Amongst the two character combinations, tillers per plant and 1000-grain weight combination recorded highest relative efficiency of 2.12, while amongst the three character combinations, it was tillers per plant + spikelets per ear + 1000-grain weight combination with 2.36 relative efficiency over direct selection for grain yield. In case of four character combination, tillers per plant + spikelets per ear + grains per ear + 1000-grains weight combination expressed highest expected genetic advance (19.61) with 2.86 relative efficiency. However, maximum relative efficiency (2.92) was achieved only when all the five characters were included in the index.

In order to make judicious and optimum use of resources at our disposal, it would be desirable to include not many characters in a selection programme. In the present study, selection index based on four characters (2.86) gave quite comparable predicted genetic advance when compared with all the five characters (2.92). Thus, it could be concluded that the characters i.e., tillers per plant, 1000-grain weight, spikelets per ear and grains per ear considered jointly, and tillers per plant and 1000-grain weight even individually offer good promise for improvement in grain yield rather than selection based on grain yield *per se* specifically in saline-sodic soils.

Table 1. Selection indices, expected genetic advance and relative efficiency in salinity tolerant wheat germplasm

Selection Index	EGA	R.E.
Grain yield/plant	8.67	1.00
0.83×1	2.48	0.48
3.19×2	13.44	1.79
2.24×3	4.01	0.80
1.45×4	3.69	0.67
2.98×5	12.05	1.62
$0.92X_1+2.94X_2$	14.78	1.98
$1.06X_1+2.16X_3$	3.94	0.86
$1.16X_1+1.40X_4$	3.48	0.78
$1.01X_1+2.68X_5$	12.77	1.46
$3.07X_2+2.11X_3$	13.99	1.96
$2.76X_2+1.56X_4$	13.72	1.67
$2.91X_2+2.44X_5$	17.61	2.12
$2.21X_3+1.41X_4$	4.47	0.94
$1.88X_3+2.56X_5$	10.08	1.40
$1.38X_4+2.75X_5$	11.63	1.67
$0.81X_1+3.10X_2+1.91X_3$	14.31	1.99
$0.92X_1+2.46X_2+1.04X_4$	14.77	2.08
$1.08X_1+3.04X_2+2.41X_5$	17.26	2.31
$0.76X_1+2.01X_3+1.24X_4$	4.08	1.36
$0.89X_1+2.26X_3+2.76X_5$	13.66	1.82
$0.93X_1+1.30X_4+2.51X_5$	12.73	1.66
$2.76X_2+2.04X_3+1.40X_4$	14.32	2.03
$3.11X_2+2.13X_3+2.74X_5$	18.84	2.36
$2.88X_2+1.46X_4+2.72X_5$	17.19	2.20
$2.04X_3+1.16X_4+2.42X_5$	14.23	1.70
$0.91X_1+3.12X_2+2.00X_3+1.07X_4$	15.04	1.84
$0.81X_1+3.23X_2+2.11X_3+2.76X_5$	17.86	2.48
$0.90X_1+3.26X_2+2.00X_4+2.41X_5$	17.06	2.57
$0.70X_1+1.46X_3+1.70X_4+2.41X_5$	13.46	1.79
$3.11X_2+2.14X_3+1.21X_4+3.01X_5$	19.61	2.86
$0.79X_1+2.78X_2+2.21X_3+1.46X_4+2.88X_5$	20.09	2.92

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COLONIZATION AND ESTABLISHMENT OF *AZOSPIRILLUM* IN DRY SEEDED RICE UNDER DIFFERENT SOIL MOISTURE LEVELS

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ABSTRACT

A field experiment was conducted to see the effect of different soil moisture levels on colonization and survival of *Azospirillum* species in the rhizosphere of dry seeded rice crop. Soil moisture levels were found to influence the extent of root colonization and persistence of *Azospirillum* in the rhizosphere. Preferential stimulation of a given *Azospirillum* species in the rhizosphere of a host genotype (var. PL-40) was observed. The population was higher in rice roots compared to rhizosphere soil at all moisture levels.

Key words : Moisture levels, *azospirillum* colonization, survival.

Soil moisture content affects microbial activity in addition to its role in soil gas exchange and a variety of chemical reactions. The water in soil flows from an area of submerged/puddled soil conditions but in recent time, dry seedling method of rice cultivation is gaining popularity especially in Northern India. Also application of *Azospirillum* biofertilizer for cultivation of rice is a common practice as it provides nearly 20-30% nitrogen requirement as well as growth promoting factors.

Water potential in soil has a profound effect on soil micro-organisms and microbial processes. As the soil water becomes limited, microbial movement becomes limited. *Azospirillum* is a microaerophilic organism and is differentially attracted to oxygen gradient (Barak *et al.* 1983). Soil moisture content influences the extent of soil aeration and this may influence the type of micro-organisms and their extent of survival. A field experiment was conducted to assess the influence of *Azospirillum* inoculation, and its establishment in dry seeded rice under different soil moisture levels. The soil moisture content was estimated periodically by gravimetric method. Upon interpolating from standard soil moisture retention curve. The soil water potential of four soil moisture regimes were recorded as -0.05, -0.10, -0.5, -1.2 Mpa. The moisture regimes selected were from near field capacity (approximately -0.05 Mpa) to nearly wilting point (-1.2).

The influence of soil moisture on the persistence and multiplication of *azospirilla* in the dry seeded rice rhizosphere was studied.

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MATERIALS AND METHODS

Rice (var. PL-40) seeds were coated with charcoal based *Azospirillum* culture having 10^9 cell/gm.

The moisture content of soil at different levels of tension (0.33 to 15 bar) was found in a pressure plate apparatus. The moisture content was plotted against the tension and standard moisture retention curves were prepared. The water potentials at different moisture levels were then inferred or interpolated linearly from standard moisture retention curves.

The moisture content of soil sample was determined at different stages of plant growth (45 and 60 DAS) by drying them to a constant weight in a hot air oven 100°C (Bannister, 1976).

Composite rhizosphere soil or rice roots were used. Adequate dilutions (10^{-2}-10^{-8}) were made in mineral salt solution (NFB without Malate) and 1 ml portions were inoculated into the tubes containing semisolid NFB medium. The inoculated tubes were replicated five times and incubated for 72 hr at 35°C. MPN counts were calculated from the tube of Alexander (1982).

RESULTS AND DISCUSSION

Rhizosphere persistence

The *Azospirillum* population of the rhizosphere of inoculated rice was significantly more than the uninoculated plants at all the four moisture regimes. The ability of *Azospirillum* to persist in rhizosphere was also dependent on the type of species. The population of *Azospirillum* species Sp7 was recorded higher than *Azospirillum* Sp cd. at all the four soil moisture regimes. At water regime W_2 = -0.1 MPa, maximum number were recorded which indicates that growth and multiplication is favoured by this moisture regime.

The maximum decline in *Azospirillum* population was observed at 60 DAS under soil moisture level -1.20 MPa. This trend was more pronounced in rhizosphere of rice inoculated with Sp cd as compared to Sp^7. This may be possibly because of extreme moisture stress (near wilting point) hindering the mobility of inoculant strain.

Table 1 shows that at W_2 moisture regime, higher population counts of both inoculated strains were observed than at near field capacity moisture level (W_1). This may be because of microaerophilic nature of *Azospirillum*. Therefore, W_2 favours better survival or persistence compared to W_1 moisture level. The relatively good survival of *Azospirillum* at low soil moisture levels (W_4) may be attributed to their ability to form resting cysts which enables them to tide over deleterious physical conditions (Sadasivan and Neyra, 1987).

Root colonization

Azospirillum population was invariably higher inside the rice roots than the respective rhizosphere at 40 DAS. The increase was significant with inoculated plants as compared to uninoculated counterparts at different soil moisture regimes. *Azospirillum* Sp7 strain showed higher root colonization compared to *Azospirillum* Sp cd. strain in rice var. PL-40. This may be because of better survival/ persistence of Sp7 strain than Sp cd. in the rhizosphere soil (Table 1). Root colonization was significantly higher at W_3 level in case

Table 1. ***Azospirillum*** **population in the rhizosphere of dry seeded rice (var. PL-40) under different soil moisture regimes (log x azospirilla/g rhizosphere soil)**

Treatment	Soim moisture level							
	W_1 = -0.05 M Pa		W_2 = -0.1 M Pa		W_3 = -0.5 M Pa		W_4 = -1.20 M Pa	
A. brasilense strain	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Sp. cd.	4.25	2.62	4.46	2.96	3.82	2.16	3.00	1.22
Sp7	4.52	2.12	4.82	3.20	4.08	2.50	3.28	1.65
Uninoculated control	2.40	0.85	2.18	1.05	2.08	1.20	2.00	0.80

MPN estimates are presented within 95% confidence limit (de Man, 1975)

of Sp7 but W_2 level showed significantly higher colonization in *Azospirillum* Sp cd. culture. This again shows the strain specificity/preference with respect to root colonization of rice var. PL-40 was more with *Azospirillum* strain Sp7 than *Azospirillum* strain Sp cd. irrespective of the soil moisture regime. The strain specific attraction is attributed to the root exudation of plants and chemotaxis ability of strains (Barak *et al.* 1983).

Table 2. Root colonization of ***Azospirillum*** **inoculated rice (var PL-40) under different moisture levels at 40 DAS of rice under dry seeding cultivation practice. (logx cells/gm unsterilised roots)**

Treatment	Soil moisture levels			
A. brasilense strain	W_1 = -0.05 MPa	W_2 = -0.10 MPa	W_3 = -0.5 MPa	W_4 = -1.20 MPa
Sp. cd.	5.38	5.53	5.00	4.28
Sp7	5.34	5.82	6.09	5.02
Uninoculated control	1.02	1.6	0.72	0.80

MPN estimates are presented within 95% confidence limit (de Man, 1975)

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STUDY OF OUTPUT-INPUT RATIOS AT VARIOUS LEVELS OF CULTURAL PRACTICES AT OPTIMUM LEVELS OF FERTILIZER NUTRIENTS FOR VARIOUS CROPS

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ABSTRACT

It is expected that response of fertilizers will change as per various levels of cultural practices for the crop. For efficient crop inputs use, it is necessary to have information on suitable combinations and the optimum level under different soil climatic conditions. This information is generally obtained from the results of field experiments testing combinations of inputs such as nitrogen, phospshorous, potash, cultural practices and irrigation etc. at different levels. The output-input relationship is established by fitting a suitable response surface model to the yield data. Choice of suitable response surface models for describing the output-input relationship is one of the important steps in fertilizer use research. This is a measure of production per unit of given input singly or jointly that is expected under the typical agronomic and climatic conditions of the region and were calculated by complete quadratic response surface model at various levels of cultural practices at optimum level of fertilizer. In most of the states, early and late harvesting of sugarcane are not beneficial for maximum sugarcane yield at optimum level of fertilizer. In case of cultural practices of spacing and plant population for various crops, it was observed that optimum level of spacing and plant poopulation at optimum dose of fertilizer exist in between lower and higher level of spacing and plant population used in the agricultural field experiments. In case of cultural practicess of mulching, it was observed that there was positive correlation between yield and quantity of residue used for mulching.

Key words : Output-input ratio, cultural practices, fertilizer, response surface model, agricultural field experiments.

Agricultural production depends not only on environmental factors such as climate, soil fertility but also on several crop improvement measures like fertilizers, manures, improved crop varieties, irrigation, double cropping, land reclamation, plant protection measures and cultural practices etc. Among various inputs of the crop, fertilizer is most important and very costly. Indian government is giving subsidy to fertilizers for farmers because they may afford the cost of fertilizers and buy as per requirement for their crop cultivation. The cultural practices are very economical and play a significant role in production of the yield of various crops. These cultural practices i.e., seed rate, spacing, date of sowing or planting, date of harvesting, number of seeds or seedling/hill, mulching with varying type of residue, method of sowing or planting, method of ploughing and cultivation etc., are economically cheaper than other inputs for the crop growth. The cultural treatments may be helpful to reduce the quantity of fertilizer and increase the crop production. One of the most important tasks in agriculture planning is fixation of targets for additional production. Targets are fixed by taking into consideration of various developmental measures that are expected to contribute to the improvement in agricultural production. Several improvement measures such as use of fertilizers, manures, improved varieties, cultural practices, plant protection etc. are being recommended to step up agricultural production. To prepare targets of additional production from the adoption of improvement measures, a knowledge of the output-input ratio is necessary. This ratio is a measure of production per unit of given improvement measures singly or jointly that is expected under the typical agronomic and climatic conditions of the region.

For efficient crop inputs use, it is necessary to have information on suitable combinations and the optimum level under different soil climatic conditions. This information is generally obtained from the results of field experiments, testing combinations of inputs such as nitrogen, phosphorous, potash, cultural practices and irrigation etc. at different levels. The output-input relationship is established by fitting a suitable response surface model to the yield data and choice of suitable response surface models for describing the output-input relationship is one of the important steps in fertilizer use research.

Output-input ratio must be based on rigorous scientific data obtained from experimental programs or from practical experience such as is secured from scientifically planned and other investigations. Singh *et al.* (1986) studied on plant geometry and nitrogen fertilization of hybrid sorghum. Kaur *et al.* (1992) published a report on statistical evaluation of fertilizer requirement according to date of sowing. They have given the results of analysis of data from these experiments conducted under AICARP in respect of rice and wheat crops on the varietal performance and fertilizer requirements in relation to the normal/delayed sowing. Study indicates that loss in yield due to dates of sowing can be compensated by adjusting the fertilizer dose to some extent and identify some varieties of rice and wheat best suited for normal/delayed sowing.

Keeping this view, an attempt was made to obtain output-input ratios at various levels of cultural practices for various crops.

MATERIALS AND METHODS

Different types of experiments are conducted at various research stations on different crops like cereals, pulses, cash crops, oilseeds and vegetables etc. in the country. Under the Project of Agricultural Field Experiments Information System, the experimental data relating to agricultural field experiments conducted at various research stations are being collected at the IASRI, New Delhi. Presently the data contains the details of 14000 experiments (excluding purely varietal experiments) till June 2000. Depending upon the nature of treatments, experiments had been classified in various types such as Manurial (M), Cultural (C), Irrigational (I), Disease, pest and weed control measures (D), Cultural cum manurial (CM), Cultural cum varietal (CV) and their other combination are with variety and cultural practices, if any.

For the purpose of present study, the data of cultural cum manurial experiments have been utilized. These experiments have the factorial structure of treatments. In the treatments, one factor is cultural practices such as spacing, seed rates, date of sowing, date of harvesting, method of sowing or planting, method of ploughing etc. While other factors are fertilizers. In the present study, plot wise yield data of these experiments are required and were analyzed for the study of presence of interactions, thereby suggesting to fit a suitable response surface model for cultural cum manurial experiment. For this, three types of models are fitted for the cultural cum manurial experiments. These models are :

$$y = a + bx + cx^2 + dz + \varepsilon \qquad \text{(i}$$

$$y = a + bx + cz + dx^2 + ez^2 + fxz + \varepsilon \qquad \text{(ii}$$

$$y = a + bx + cz + dx^2 + fxz + \varepsilon \qquad \text{(iii}$$

where y is observed yield, x and z are the inputs for fertilizer and cultural practices, respectively. Only those cultural practices are involved in the model which are quantitative nature e.g., mulch, seed rate, spacing, duration of crop (time of harvesting) etc.

Output-input ratio

A output-input ratio, as the name implies, is a ratio between total output (yield) measured in some manner and the input applied (quantity of fertilizer). After fitting response surface model, we find the yield (y_{mn}) at optimum level (m) of fertilizer and required level (n) of cultural practice and calculated the output-input ratio as follows:

$$\text{Output-input ratio} = \frac{y_{mn}}{m}$$

RESULTS AND DISCUSSION

On the basis of coefficient of determination (R^2) and root mean square error (S.E.), the model (ii) is found to be best fitted for cultural cum manurial experiments. In most of cases, optimum doses of fertilizer and cultural practices are found within range of doses which were taken in the treatments of the experiments. In most of the cases, linear effects of both fertilizer and cultural practices are observed positive but quadratic effects in both the cases are found negative. Interaction effects are found positive in 50% cases and negative in 50% cases in model ii (complete quadratic response surface model) which is found suitable for cultural cum manurial experiments.

Output-input ratio

In most of the cases, output-input ratios were calculated by Model ii at various levels of cultural practices at optimum level of fertilizer (Table 1). In Andhra Pradesh, range of out-input ratios for sugarcane crop was (5.46-9.24 q/kg) and optimum level of cultural practice for harvesting times was observed 12.96 months after planting at optimum level of 119.7 kg/ha of K_2O.

In Bihar, range of out-input ratios for sugarcane crop was (4.93-5.86 q/kg) and optimum level of cultural practice for

Table 1.Output-input ratios of various crops at various levels of cultural practices when optimum level of fertilizer used

S.No.	State/Name of research station	Crop/Variety/ Season	Name and optimum level of fertilizer nutrient	Name and levels of cultural practices	Output-input ratio	Model used
1.	Andhra Pradesh Agril. Res. Stn. Anakapalli	Sugarcane CO. 7706 Irrigated	119.7 kg/ha of K_2O	Harvesting Times 12 months after planting	8.86 q/kg	ii
				14 -do-	8.79 q/kg	
				16 -do-	5.46 q/kg	
				12.96 -do- (optimum level)	9.24 q/kg	
2.	Bihar S.Cane Res. Instt.,Pusa (Samastipur)	Sugarcane BO.91 Irrigated	135.9 kg/ha of K_2O	10 -do-	5.59 q/kg	ii
				11 -do-	5.85 q/kg	
				12 -do-	5.64 q/kg	
				13 -do-	4.93 q/kg	
				11.04 -do- (optimum level)	5.86 q/kg	
3.	Karnataka Regional Res. Stn., Malya	Sugarcane CO. 419 Irrigated	151.9 kg/ha of K_2O	12 -do-	9.56 q/kg	iii
				14 -do-	10.26 q/kg	
				16 -do-	10.97 q/kg	
4.	Regional Res. Stn. Bijapur	Sorghum Muguti Unirrigated Rabi	55.76 kg/ha of N	Plant population		
				45 thousands plants/ha	27.06 kg/kg	ii
				90 -do-	35.46 kg/kg	
				135 -do-	37.69 kg/kg	
				190 -do-	32.02 kg/kg	
				128.79 -do- (optimum level)	37.78 kg/kg	
5.	Tobacco Res. Stn., Hunsuk	Tobacco FCH-6005 Kharif	34.72 kg/kg of N with two and half times of P_2O_5 and K_2O	Spacings	44.22 kg/kg	ii
				40 cm.	44.35 kg/kg	
				50 cm.	42.53 kg/kg	
				60 cm.	44.60 kg/kg	
				45.73 cm. (Optimum level)		
6.	Maharashtra Regional S. Cane Res. Stn. Kolhapur	Sugarcane Irrigated	175.89 kg/ha of K_2O	Harvesting dates 10 months after planting	4.38 q/kg	ii
				12	7.95 q/kg	
				14	8.00 q/kg	
				16	7.84 q/kg	
				13.49 (Optimum level)	8.00 q/kg	

contd...

Table 1 contd...

7.	Dry Farming	Sorghum	59.08 kg/ha	Quantity of residue		ii
	Res. Stn.	M.35-I	of N	used for mulching		
	Sholapur	Kharif		0 tons/ha	7.51 kg/kg	
		Rainfed		2.5 -do-	12.26 kg/kg	
				5.0 -do-	15.49 kg/kg	
				7.5 -do-	17.20 kg/kg	
				9.05 -do-(Optimum level)	17.50 kg/kg	
8.	College of Agril.	Wheat	160.03	Seed rates		
	Kolhapur	HD 2189	kg/ha of N	100 kg/ha	22.86 kg/kg	ii
		Rabi irrigated	with half	125 kg/ha	22.91 kg/kg	
			times dose	150 kg/ha	22.74 kg/kg	
			of P_2O_5 and	175 kg/ha	22.34 kg/kg	
			K_2O	118.60 kg/ha	22.92 kg/kg	
9.	College of Agril.	Nagli	77.18 kg/ha	Row spacings	22.06 kg/kg	i
	Kolhapur	B-11	of N	20 cm.	20.64 kg/kg	
		Kharif		30 cm.	18.53 kg/kg	
		Unirrigated		45 cm.		
10.	Agril. Res. Stn.	Tobacco	55.54 kg/ha	Spacing		
	Digraj (Sangli)	S-20	of N	45 cm.	19.85 kg/kg	ii
		Kharif		60 cm.	21.50 kg/kg	
		irrigated		90 cm.	15.00 kg/kg	
				43.62 cm.	21.69 kg/kg	
				(Optimum level)		
11.	Maharashtra	Sorghum	65.78 kg/ha	Plant population		
	Mahatama Phule	SPV.504	of N	40 thousand plants/ha		
	Agril. Univ,	Kharif rainfed		80 -do-	33.0 kg/kg	ii
	Rahuri			120 -do-	35.10 kg/kg	
				160 -do-	35.30 kg/kg	
				104.8 -do-	33.68 kg/kg	
				(Optimum level)	35.44 kg/kg	
12.	-do-	-do-	54.23 kg/ha	Plant population		
			of N	40 thousand plants/ha		
				80 -do-	43.36 kg/kg	ii
				120 -do-	48.16 kg/kg	
				160 -do-	51.01 kg/kg	
				159.87 -do-	51.75 kg/kg	
				(Optimum level)	51.95 kg/kg	
13.	U.P.	Mustard	133.11 kg/ha	Row spacings		
	Allahabad Agril.	Varuna	of N	50 cm.	9.41 kg/kg	ii
	Instt., Allahabad	Rabi		75 cm.	9.62 kg/kg	
		Irrigated		100 cm.	9.40 kg/kg	
				74.7 cm.	9.62 kg/kg	
				(Optimum level)		

contd...

Table 1 contd...

14.	-do-	Soybean	35.14 kg/ha	Row spacings		
		Gaurav	of N	40 cm.	49.51 kg/kg	ii
		Kharif		50 cm.	53.93 kg/kg	
		Irrigated		60 cm.	52.80 kg/kg	
				52.56 cm.	54.11 kg/kg	
				(Optimum level)		
15.		Mustard	70.69 kg/ha	Row spacings		
		R.K. 148	of N	30 cm.	13.52 kg/kg	ii
		Rabi		45 cm.	14.18 kg/kg	
		Unirrigated		60 cm.	13.17 kg/kg	
				43.5 cm.	14.19 kg/kg	
				(Optimum level)		
16.	R.B. College	Tomato	188.81 kg/ha	Plant spacings		
	Bichpuri	HS-102		30 cm.	0.6828 q/kg	
		Rabi		40 cm.	0.7180 q/kg	
		Irrigated		50 cm.	0.6490 q/kg	
				60 cm.	0.4838 q/kg	
				38.27 cm.	0.7140 q/kg	
				(Optimum level)		
17.	U.P.	Sugarcane	177.55 kg/ha	Time of harvesting		
	S.Cane.Res.	Co-767	of K_2O	10 months after planting	3.87 q/kg	i
	Instt., Shahajapur	Irrigated		12 -do-	3.89 q/kg	
				14 -do-	3.90 q/kg	

harvesting times was observed 11.04 months after planting at optimum level of 135.9 kg/ha of K_2O.

In Maharashtra, range of out-input ratios for sugarcane crop was (4.38-8.00 q/kg) and optimum level of cultural practice for harvesting times was observed 13.49 months after planting at optimum level of 175.89 kg/ha of K_2O.

In Karnataka, range of out-input ratios for sugarcane crop was (9.56-10.97 q/kg) and optimum level of cultural practice for harvesting times was observed 16 months after planting at optimum level of 151.9 kg/ha of K_2O.

In Uttar Pradesh, range of out-input ratios for sugarcane crop was (3.87-3.90 q/kg) and optimum level of cultural practice for harvesting times was observed 14 months after planting at optimum level of 177.5 kg/ha of K_2O.

In case of cultural practices of spacing and plant population for various crops, it was observed that optimum level of spacing and plant population at optimum dose of fertilizer exist in between lower level and higher level of spacing and plant population used in the agricultural field experiments (Table 1).

In case of cultural practices of mulching, it was observed that there was positive correlation between yield of crop and quantity of residue which was used for mulching. It was found that higher dose of mulching material was beneficial for maximum crop production (Table 1).

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RESPONSE OF LUCERNE VARIETIES TO LEVELS OF PHOSPHORUS AND POTASSIUM

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Abstract

Field studies were undertaken at Palghar (Maharashtra) during Rabi season of 1992-93, 1993-94 and 1994-95 to estimate the phosphorus and potassium requirements of Lecerne varieties for maximizing the green as well dry forage production. Results revealed that the variety Anand - 2 gave significantly higher dry fodder yield over Anand - 3 in the pooled data. However, the green fodder yield differences due to both the varieties were nonsignificant. Application of P_2O_5@150 kg/ha and potassium @ 50 kg/ha produced significantly higher green fodder yield of Lecerne. Application of phosphorus @ 150 kg/ha produced maximum dry fodder yield which was at par with 100 kg P_2O_5/ha and significantly higher over remaining levels of phosphorus. Application of K_2O @ 50 kg/ha gave significantly higher dry fodder yield over control. Application of phosphorus @ 150 kg/ha and K_2O @ 50 kg/ha to Lucerne variety Anand-2 gave significantly higher green fodder yield over Anand - 3 whereas both the varieties equally responded to 150 kg P_2O_5 and 50 kg K_2O/ha as far as dry fodder yield was concerned.

Key words : Lucerne, phosphorus, potassium and levels.

Year round supply of forage is very important in order to stablize animal produciton especially in milkshed areas and also for small farmers who maintain dairy animals as a regular source of income. Lucerne (*Medicago sativa* L.) is one of the important forage crops of Maharashtra. Fodder production in India is not sufficient to fulfill the requirement of livestock population and forages produced are of poor quality. Inadequate supply of nutritious forage and feeds is one of the reasons for poor milk yields of cows and buffaloes in our country. The diversion of newer area for forage cultivation would not be possible because of preferential treatment of human food and other economic compulsions. Under such circumstances, the only way to bridge the wide gap between demand and supply is to ameliorate forage resources through increased productivity from a unit area. Fertilizer management is the important respect which helps in harnessing the potential yield improving quality to forages (Sardana and Narwal, 1999). Keeping this in view, the present study was undertaken to estimate the phosphorus and potassium requirement of Lucerne under agroclimatic conditions of Konkan.

Materials and Methods

The field experiment was conducted at

Grass Breeding Station, Palghar, Dist. Thane (Maharashtra) during *Rabi* hot weather season 1992-93, 1993-94 and 1994-95, with the object to estimate the phosphorus and potassium requirement of Lucerne varieties viz. Anand - 2 and Anand - 3. The experiment was laid out in split plot design with three replications. Gross plot size was 5m × 4 m and net plot size was 4.5m × 3.5m. The treatments comprised two varieties (Anand-2 and Anand-3) in main plots and four levels of phosphorus (0, 50, 100 and 150 kg P_2O_5/ha) and two levels of potassium (0 and 50 kg K_2O/ha) in sub plots. The soil of the experimental field was medium black, alkaline in reaction, medium in available nitrogen and available phosphorus and rich in available potash. Crop was sown at 25 cm row spacing during the last week of November. Basal dose of 25 kg N/ha was applied at the time of land preparation. Need based weedings and plant protection measures were followed. Data on green fodder and dry fodder yield was recorded during each year. Data were analyzed statistically.

RESULTS AND DISCUSSION

Effect of varieties

Data presented in Table 1 revealed that during all the three years of study and also in the pooled data, the green fodder yield of Lucerne. As regard the dry fodder yield, both the varieties showed nonsignificant differences during the individual season whereas in the pooled data, cv. Anand - 2 recorded significantly higher dry fodder yield over Anand - 3.

Effect of phosphorus

During all the seasons and in the pooled data green as well as dry fodder yield of Lucerne was significantly influenced by different levels of phosphorus under study. Application of phosphorus @ 150 kg/ha registered significantly higher green fodder yield over all other levels during 1992-93, 1993-94 and in the pooled data. However, during 1994-95, application 150 kg P_2O_5/ha was significantly superior over 0 and 50 kg P_2O_5 and at par with 100 kg P_2O_5/ha.

As regards the dry fodder yield, application of 150 kg P_2O_5 gave significantly higher yield during 1992-93 and 1993-94. However, during 1994-95 and in the pooled data, application of 150 kg P_2O_5/ha was at par with 100 kg P_2O_5/ha and significantly superior over remaining phosphorus levels under study. Kumar and Yadav (1999) also observed higher green fodder yield of leguminous fodders with higher level of phosphorus.

Effect of potassium

During all the three seasons and also in the pooled data, application of potassium @ 10 kg/ha significantly increased the green fodder as well dry fodder yield of Lucerne (Table 1).

Effect of interaction

Interaction between variety, phosphorus and potassium levels were found significant in the pooled data (Table 2). Application of phosphorus @ 150 kg/ha and potassium @ 50 kg/ha to Lucerne variety Anand - 2 gave significantly higher green fodder yield over all other combinations. Similarly, application of phosphorus @ 150 kg/ha and potassium @ 50 kg/ha produced maximum dry fodder yield which was at par with the yield recorded by Anand - 3 at the same level of fertilization and significantly higher over rest of the combinations.

Table 1. Green fodder yield and dry matter yield (q/ha) of Lucerne varieties as affected by different treatments

Treatments	1992-93		1993-94		1994-95		Pooled mean	
	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield	Green fodder yield	Dry matter yield
Varieties								
Anand - 2	264.73	64.08	315.67	68.16	542.81	115.98	374.40	82.74
Anand - 3	275.05	65.34	272.28	61.35	528.14	113.18	258.49	79.96
S.Em. ±	4.54	9.01	30.45	0.77	2.47	1.30	3.87	3.38
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	11.66
P_2O_5 levels (kg/ha)								
P_0	212.66	46.23	255.45	56.04	486.08	103.60	318.04	68.62
P_{50}	260.63	70.09	286.45	62.89	523.62	110.42	356.92	81.14
P_{100}	289.54	68.70	301.59	66.21	559.18	118.92	383.44	84.61
P_{150}	316.67	73.81	332.41	73.89	573.06	125.38	407.33	91.03
S.E. ±	6.72	1.41	5.41	1.04	8.25	2.47	2.38	3.83
C.D. at 5%	19.49	4.10	15.69	2.99	25.91	7.17	6.59	10.76
K_2O levels (kg/ha)								
K_0	263.85	62.35	263.63	58.52	508.64	110.29	345.37	77.06
K_{50}	275.93	67.07	324.32	70.99	562.30	118.87	287.52	85.64
S.E. ±	4.75	1.0	3.82	0.73	5.83	1.75	3.79	0.55
C.D. at 5%	N.S.	2.9	11.09	2.12	16.91	5.07	10.50	1.52

Table 2. Effect of interactions (Pooled) between varieties, phosphorus and potash levels on the green fodder yield (q/ha)

Treatments	Anand-2				Anand-3			
	P_0	P_{50}	P_{100}	P_{150}	P_0	P_{50}	P_{100}	P_{150}
K_0	288.76	336.82	371.20	297.51	297.59	328.97	372.41	258.60
K_{50}	350.23	395.31	400.96	454.42	324.46	366.58	389.20	418.99
S.E. ±	14.31							
C.D. at 5%	39.67							

Table 3. Effect of interactions (Pooled) between varieties, phosphorus and potash levels on the dry matter yield (q/ha)

Treatments	Anand-2				Anand-3			
	P_0	P_{50}	P_{100}	P_{150}	P_0	P_{50}	P_{100}	P_{150}
K_0	63.93	76.02	78.54	89.72	66.01	76.51	85.01	80.72
K_{50}	74.45	89.49	88.79	101.00	70.11	82.52	86.11	92.69
S.E. ±				3.89				
C.D. at 5%				10.80				

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RESPONSE OF SUMMER MOONG (*VIGNA RADIATA* L.) TO LEVELS OF PHOSPHORUS AND PSM INOCULATION IN SANDY LOAM SOIL

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ABSTRACT

The present study was conducted during kharif seasons of 1999 & 2000 to evaluate the levels of phosphorus (0, 30, 60 and 90 kg ha^{-1}), with or without PSM on summer moong. Grain and stover yields of moong increased due to application of P alone as well as inoculation with Phosphorous solubilizing Microbes (PSMs). The application of P significantly increased the grain yield upto 60 kg ha^{-1}. Similarly, inoculation with PSM increased the grain yield when compared with uninoculation. However, the effect was limited with the application of 60 kg P_2O_5 ha^{-1} in both grain and stover yields. Both phosphorus and PSM inoculation significantly influenced the content and uptake of N, P and K in moong crop.

Key words : Phosphorus levels, phosphorus solubilizing microbes, uptake and *Vigna radiata* L.

Moong (*Vigna radiata* L.) is the most dominant pulse crop in India. The crop is mainly grown as per rabi crop during September-October in the marginal lands of sandy loam soils. Moong cv. K-851 is a short duration (65-70 days) crop. Hence, it fit well in the cropping sequences and inoculation of pulse crops increases the fertility status of the soil. Phosphorous nutrition is of a special significance in moong production. Besides its role in metabolic processes and energy transformation, P considerably influences root proliferation which are the seat of biological N fixation and helps plants draw nutrients from lower layers and consequently thrive under moisture stress conditions, generally prevailing in moong growing region. In the recent years, the escalation in prices of P fertilizers has led to considerable decreases in its use. It is therefore, imperative to enhance the efficiency of natural as well as applied P.

MATERIALS AND METHODS

A field experiment was conducted during kharif season (1999 and 2000) on sandy loam soil testing pH 8.3. Ec 0.14 dSm^{-1}, free Ca CO_3 5.0 g kg^{-1}, available N 162.5 kg ha^{-1}, available P 9.8 kg ha^{-1} and available K 144.0 kg ha^{-1}, at R.B.S. College Research Farm, Bichpuri (Agra). The treatments consisted of four levels of Phosphorus (30, 60, 90 kg P_2O_5 ha^{-1}) and two levels of PSM (with and without PSM) were conducted in the split plot design with

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three replications. Plants were harvested at ground level at 65 days after sowing for recording the grain and stover yields. After determining fresh weight, the plant tops were dried in an oven at 60°C for 72 hours and dry weight were recorded. Nitrogen was estimated by kjeldahl method. The phosphorous was estimated by molybdo-vanadophosphate method and the K was determined directly on flame photometer.

RESULTS AND DISCUSSION

Grain and stover yields

The levels of phosphorus (Table 1) showed significant increase in grain yield over control. The grain yield was increased by 0.125, 0.523 and 0.251% respectively with 30, 60, 90 kg P_2O_5 ha^{-1} application over control. This increase in the grain yield with the application of phosphorus may be because of more number of pods and seeds. Verma and Srivastava (1985) have also observed increased grain yield of moong with the application of phosphorus. The grain yield of moong was increased significantly with PSM inoculation. The increase in grain yield with PSM inoculation was 23.73% over uninoculation. It has been established that these are specific groups of soil microorganisms, which make the phosphorous available to plants, not only by mineralizing organic phosphorus compounds but also by rendering inorganic phosphorous compounds more available (Gaur et al. 1980; and Dubey, 1996). Data pertaining to stover yield clearly indicate that different levels of phosphorus produced significantly higher stover yield. In this respect 60 kg P_2O_5 ha^{-1} resulted into highest stover yield during both the years followed by 90 and 30 kg P_2O_5 ha^{-1}, while, lowest stover yield was recorded in control. These finding are in agreement with the findings reported by Verma and Srivastava (1985). The PSM inoculation significantly increased the stover yield of moong crop over uninoculation. The stover yield of moong crop was 13.10% more with microbial

Table 1. Effect of levels of phospshorus and PSM inoculation on grain and stover yield (q ha^{-1}) of moong crop

Sources	Grain yield (qha^{-1})			Stover yield (qha^{-1})		
	1999	2000	Mean	1999	2000	Mean
Levels of P_2O_5(kg^{-1})						
Control	7.82	8.09	7.95	7.95	8.24	8.11
30	7.83	8.10	7.96	7.96	8.29	8.12
60	7.85	8.13	7.99	7.97	8.31	8.14
90	7.84	8.11	7.97	7.96	8.30	8.13
S.Em.±	0.007	0.007		0.003	0.003	
C.D. at 5%	0.020	0.021		0.009	0.010	
Inoculation						
Without inoculation	7.01	7.24	7.12	747	7.79	7.63
With inoculation	8.66	8.97	8.81	8.45	8.81	8.63
S.Em.±	0.004	0.006		0.002	0.002	
C.D. at 5%	0.014	0.019		0.008	0.007	

inoculation than that of no microbes in the cropping seasons of 1999 and 2000. Gaur et al. (1980) and Dubey, (1996) have also reported the similar results.

N, P and K content in grain and stover

The application of P @ 60 kg ha^{-1} resulted highest N content. Thereafter, a decreasing trend was seen during the course of investigation. On an average, the difference in grain N content between control and 60 kg P_2O_5 ha^{-1} was 0.273% while about 0.082% with 30 as well as 90 kg P_2O_5 ha^{-1}. The percent increases in stover N content were 0.106, 0.319 and 0.212% due to the application of 30, 60 and 90 kg ha^{-1} respectively. Singh (1971) and Jain et al. (1987) have also noticed a considerable increase in the N content in moong grain over uninoculation. The N content was 14.46% more with microbial inoculation than that of without microbes in both the years of investigation. Application of inoculation increased the N content of moong stover over uninoculation. The percent increase of N content in stover due to PSM inoculation was 14.02 over uninoculation. Similarly, all the levels of phosphorus were found to be significantly superior over control with respect to P and K content in grain and stover. P content in grain and stover were increased with increasing levels of phosphorus upto 60 P_2O_5 kg ha^{-1}. The percentage increase in P content of grain and stover over control were 0.0546, 0.2538, 0.0846% and 0.0683, 0.2732 and 0.0546% due to application of 30, 60 and 90 kg P_2O_5 ha^{-1} respectively. Trivedi (1996) have also reported that phosphorus concentration in grain and stover increased with increasing level upto 60 P_2O_5 ha^{-1}. The phosphorus content was higher in grain compared to stover. Phosphorus content in grain and stover increased with inoculation of *Pseudomonas stariata.* P percentage in grain and stover were 13.88% and 14.64% over uninoculation respectively. PSM could be attributed to increase dissolution and mobilization of soil phosphorus and ultimately improves the P nutrition of plant (Dubey, 1996).

Phosphorus application significantly increased the K content of grain and stover with increasing doses of phosphorus upto 60 kg ha^{-1}. Mean values of two years trial for K content revealed that phosphorus applied @ 30, 60 and 90 kg ha^{-1} respectively yielded 0.147, 0.443 and 0.295% more contents in grain when compared with check. Similar trend was moong stover (Table 2). These findings are in conformity with the results obtained by Jain et al. (1990). Application of Pseudomonas striata inoculant significantly increased the K content in grain and stover. The extent of increase was 115.55% due to PSM inoculation as compared to uninoculation. According to Jana et al. (1990) the availability of phosphorus helps in the absorption of K content by plants.

N, P and K uptake by grain and stover

The N uptake by grain and stover were significantly increased with the application of phosphorus upto 60 kg ha^{-1} and thereafter the uptake was decreased. Phosphorus applied @ 60 kg ha^{-1} resulted in the highest N uptake and was significantly superior over all he other levels under test. In case of grain on an average phosphorus @ 30, 60 and 90

Table 2. Effect of levels of phosphorus and PSM inoculation on content of N, P and K in grain and stover of moong crop

Sources	N content in grain			P content in grain			K content in grain			N content in stover			P content in stover			K content in stover		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Levels of $P_2O_5(kg^{-1})$																		
Control	3.615	3.702	3.658	0.3509	0.3583	0.3546	0.664	0.688	0.676	0.92	0.95	0.940	0.13	0.13	0.146	1.35	1.416	1.385
30	3.617	3.705	3.661	0.3511	0.3585	0.3548	0.666	0.689	0.677	0.92	0.96	0.941	0.14	0.14	0.146	1.36	1.421	1.390
60	3.624	3.712	3.668	0.3517	0.3593	0.3555	0.668	0.690	0.679	0.92	0.96	0.943	0.15	0.16	0.148	1.37	1.436	1.405
90	3.619	3.707	3.663	0.3512	0.3587	0.3549	0.667	0.689	0.678	0.92	0.95	0.942	0.14	0.14	0.146	1.36	1.425	1.394
SEm±	0.0019	0.0018		0.0001	0.0001		0.0003	0.0003		0.01	0.05		0.01	0.01		0.38	0.012	
C.D. at 5%	0.0053	0.0052		0.0005	0.0005		0.0009	0.0010		0.01	0.01		0.01	0.01		0.01	0.012	
Inoculation																		
Without inoculation	3.372	3.459	3.15	0.3294	0.3345	0.3319	0.626	0.642	0.634	0.86	0.89	0.877	0.13	0.13	0.136	0.86	0.910	0.884
With inoculation	3.865	3.954	3.309	0.3731	0.3829	37.80	0.708	0.736	0.722	0.98	1.02	1.000	0.22	0.16	0.157	1.86	1.938	1.901
SEm±	0.002	0.001		0.0002	0.0001		0.0002	0.0003		0.04	0.01		0.01	0.01		0.01	0.025	
C.D. at 5%	0.005	0.004		0.0005	0.0004		0.0007	0.0009		0.01	0.01		0.01	0.00		0.01	0.0081	

Table 3. Effect of levels of phosphorus and PSM inoculation on uptake (kg ha^{-1}) N, P and K in grain and stover of moong crop

Sources	N uptake by grain			P uptake by grain			K uptake by grain			N uptake by stover			P uptake by stover			K uptake by stover		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Levels of P_2O_5(kg^{-1})																		
Control	28.46	30.17	29.32	2.75	2.91	2.83	5.24	5.61	5.42	7.35	7.97	7.66	1.13	1.22	1.17	10.9	11.98	11.49
30	28.52	30.23	29.38	2.76	2.92	2.84	5.25	5.62	5.43	7.36	7.98	7.67	1.15	1.23	1.19	11.1	12.04	11.85
60	28.66	30.38	29.52	2.78	2.94	2.8	5.27	5.64	5.46	7.39	8.03	7.71	1.16	1.24	1.20	11.9	12.19	11.69
90	28.56	30.28	29.42	2.77	2.93	2.85	5.25	5.63	5.44	7.37	8.00	7.69	1.15	1.23	1.19	11.0	12.09	11.59
SEm±	0.003	0.031		0.003	0.003		0.005	0.005		0.01	0.01		0.01	0.01		0.03	0.035	
C.D. at 5%	0.087	0.087		0.009	0.009		0.013	0.016		0.01	0.01		0.01	0.01		0.08	0.099	
Inoculation																		
Without inoculation	23.64	25.05	24.34	2.30	2.42	2.36	4.38	4.65	4.51	6.45	6.95	6.70	1.01	1.07	1.04	6.42	7.09	6.73
With inoculation	33.46	35.48	34.47	3.23	3.43	3.33	6.12	6.60	6.36	8.28	9.05	8.67	1.30	1.40	1.35	15.7	17.06	16.41
SEm±	0.018	0.017		0.0014	0.0028		0.004	0.004		0.01	0.01		0.01	0.01		0.01	0.020	
C.D. at 5%	00047	00044		0.0046	0.0089		0.0121	0.014		0.01	0.01		0.01	0.01		0.01	0.064	

kg ha^{-1} gave 0.204, 0.702 and 0.347% higher N uptake, respectively, when compared with control. The Increasing levels of phosphorus significantly increased the N uptake by stover during first and second years upto 60 kg P_2O_5 ha^{-1}. The 90 kg P_2O_5 ha^{-1} resulted significantly less uptake as compared to 60 kg ha^{-1}. The higher N uptake in grain and stover may be due to the greater yield of the crop obtained with phosphorous application. The PSM inoculation exerted a highly significant effect in increasing the uptake of nitrogen by grains and stover of moong. About 41.22% more uptake was observed with inoculation over uninoculation in both the years of investigation. These results are in accordance with findings reported by Bardia et al. (1970). In the present investigation the P levels were significantly better over control for the phosphorus uptake by grain and stover during both the years. In this respect maximum value of P uptake was observed with phosphorus applied @ 60 kg ha^{-1} followed by 90 and 30 kg P_2O_5 ha^{-1}. Based on the mean values, phosphorus applied @ 30, 60 and 90 kg ha^{-1} resulted 0.211, 0.739, 0.387% and 0.169, 0.502 and 0.251% higher uptake by grain and stover respectively when compared with control. The PSM inoculation significantly increased the P uptake by grain and stover. The P uptake by grains and stover were 40.87% and 29.62% more with PSM inoculation when compared with control. An increase in the uptake of phosphorus by plants has also been seen by Kapoor et al. (1987). Each successive dose upto 60 kg ha^{-1} phosphorous to moong crop brought significant improvement in the K uptake over check. Phosphorous applied @ 60 kg ha^{-1} resulted maximum K uptake by grain and stover which were followed by 30 and 90 kg P_2O_5 ha^{-1} during both the years (Table 3) Jana et al. (1990) have also found an increasing effect of phosphorous on the uptake of K by crop. The application of PSM inoculant showed significant effect in increasing the K uptake by moong grain and stover. The extents of increase over control were 40.84% by grains and 143.64% by stover. Inoculations help in solubilizing the unavailable or fixed phosphate and improve the availability of phosphorus.

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RESPONSE OF DIFFERENT WHEAT GENOTYPES UNDER NORMAL AND LATE SOWN CONDITION

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ABSTRACT

Field experiment was conducted during rabi season of 2000-2001 and 2001-2002 at Crop Research Centre of G.B.P.U.A. & T, Pantnagar to evaluate the effect of date of sowing on yield contributing c ha r acters and yield of different genotypes of wheat. Yield contributing characters was found maximum at normal sown condition, which was significantly more over late sown condition. In different genotyeps of wheat PBW-343 gave significantly more yield contributing characters and grain yield than other genotypes during 2000-2001 while UP-2425 gave significnatly more yield over others during 2001-2002. Yield contributing characters and grain yield in normal sown condition was found maximum inPBW-343, which was at par with UP-2338 during 2000-2001 and UP-2338 Raj 3765 and UP 2425 during 2001-2002. In late sown condition UP-2425 out yielded over other genotypes of wheat. Variety UP-2338 and Raj-3765 gave better result in both normal and late sown condition.

Key words : Wheat genotypes, date of sowing, yield and yield contributing characters.

The major limitation of wheat productivity in north-India is high temperature, which influenced the wheat crop at both the ends of the crop growth (Howard, 1924). It has been observed that for every one-degree rise in mean temperature over a range of 12.2-27.5°C, wheat yield is reduced by 4 per cent (Viswanathan *et al.*, 1996). High temperature following anthesis adversely affects the grain development (Tashiro and Wardlaw, 1990), grain growth rate and grain growth period (Sofield *et al.*, 1977), consequently the final grain weight is reduced. Temperature stress is a common occurrence during grain filling stage of wheat under late sown condition. High temperature up to 30/25°C after anthesis reduces yield largely through an effect on weight per grain, rather than on grain number (Warlaw *et al.*, 1989). Blum (1988) found that the genotypic tolerance of wheat to temperature was due to the Cell membrane thermo stability (CMS) and wheat varieties show considerable variation in their performance in respect to variation in sowing time. So considering the above views an experiment was conducted to study the basis of yield variation among wheat varieties under different sowing conditions.

Materials and Methods

A field experiment was conducted during 2000-2001 and 2001-2002 at crop research centre of G.B.P.U.A. & T, Pantnagar. The climate of the site enjoys with sub-humid and sub-tropical condition and the soil of experimental field was sandy loam in texture, slightly alkaline in reaction, rich in organic carbon, low in available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in split design having three replications. Two dates of sowing Viz. 22 November and 22 December was taken in main plot and twelve wheat genotypes namely CPAN-3004, NIAW-34, PBW-343, PBW-373, RAJ-3077, RAJ-3765, UP-2003, UP-2338, UP-2382, UP-2425, WH-542 and WH-896 were taken in sub-plot. Recommended fertilizer doses (150:60:40 kg NPK/ha) were applied. Half doses of N and full doses of P, K were applied as basal and remaining dose of nitrogen was applied at the time of common irrigation.

Results and Discussion

Yield contributing characters

Delay in sowing from November 22 to December 22 significantly reduced the length of spike during both the years (Table 1). Among the varieties, PBW-343 and UP-2425 produced significantly longest spike over other varieties. Significantly more fertile spikelets was recorded in November 22 over December 22 sown crop during

Table 1. Effect of sowing dates and varieties on spike length (cm), numbers of fertile and sterile spikelets per spike of wheat

Treatments	Length of spike (cm)		Fertile spikelets		Sterile spikelets	
	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002
Sowing dates						
November 22	11.51	11.60	16.31	18.23	2.22	1.69
December 22	9.76	10.45	13.92	15.33	2.67	2.63
SEm±	0.06	0.05	0.18	0.26	0.10	0.06
C.D. (5%)	0.35	0.30	1.11	1.58	NS	0.36
Varieties						
CPAN-3004	10.20	11.10	15.17	17.17	3.00	2.23
NIAW-34	10.30	9.80	15.00	15.67	2.50	1.82
PBW-343	12.10	10.90	16.50	17.13	1.50	2.40
PBW-373	9.93	11.16	14.00	16.92	2.83	2.50
RAJ-3077	10.88	10.73	14.67	15.53	2.50	2.00
RAJ-3765	11.45	11.32	14.50	15.87	2.17	1.97
UP-2003	9.90	10.88	14.83	17.57	2.83	2.43
UP-2338	11.68	11.75	16.83	17.77	1.67	1.95
UP-2382	10.93	11.50	15.33	16.55	2.50	2.63
UP-2425	11.77	14.07	16.83	16.82	1.67	1.87
WH-542	10.28	10.37	13.83	17.22	3.33	2.28
WH-896	8.22	8.52	13.83	16.62	2.83	1.85
C.D. (5%)	0.60	0.23	1.10	0.38	0.72	0.27

both the years. Significant differences among the varieties were observed in variety UP-2425 and UP 2338 from other varieties, but it was at par with PBW-343. Delayed sowing significantly increased the number of sterile spikelets per spike. The maximum number of sterile spikelets was produced by WH-542 and UP-2382 during 2000-2001 and 2001-2002, respectively.

Significantly highest number of grains per spike was produced by UP-2003 which was at par with WH-542 during 2000-2001. Whereas, UP-2338 recorded highest number of grains than other varieties during 2001-2002 (Table 2). Delay in sowing significantly reduced the number of grains per spike during both the years. It might be fact that late sown crop faces higher temperature during reproductive growth. Wardlaw et al. (1989) reported that grain number was most sensitive to temperature after anthesis.

Significant reduction in grain weight per spike was observed with delay in sowing from November 22 to December 22 during both the years. The low grain weight of the ears is primarily due to deleterious effect of ascending temperature during the grain filling period on grain size and grain growth duration (Wiegand and Cuellar, 1981). Sowing later than November 22 resulted in significant reduction in thousand grain weight which as also been reported by Ansari et al. (1989) and Das et al. (1995). Significantly higher 1000-grain weight was

Table 2. Effect of sowing dates and varieties on numbers of grain per spike, grain weight per spike (g) and thousand grain weight (g) of wheat

Treatments	Number of grains/spike		Grain weight/spike (g)		1000-grain weight (g)	
	2000-2001	2001-2002	2000-2001	2001-2002	2000-2001	2001-2002
Sowing dates						
November 22	50.89	52.00	1.93	2.29	38.49	43.20
December 22	45.81	43.60	1.54	1.57	34.39	35.00
SEm±	0.22	0.06	0.03	0.02	0.26	0.26
C.D. (5%)	1.32	0.36	0.17	0.13	1.59	1.55
Varieties						
CPAN-3004	51.50	52.32	1.44	1.83	27.88	33.72
NIAW-34	44.33	41.67	1.66	1.91	39.34	45.78
PBW-343	47.00	48.88	1.82	2.03	39.89	40.72
PBW-373	41.17	48.90	1.361	1.94	38.83	39.13
RAJ-3077	46.33	43.28	1.56	1.72	33.65	38.70
RAJ-3765	46.50	46.58	1.78	1.90	38.34	40.00
UP-2003	57.00	48.23	1.70	1.95	29.76	37.78
UP-2338	50.00	52.43	2.02	2.21	40.40	41.19
UP-2382	51.17	48.17	1.83	1.74	35.52	34.68
UP-2425	38.83	47.62	2.08	2.48	53.51	50.57
WH-542	56.33	49.63	1.59	1.74	28.11	34.24
WH-896	50.00	45.90	1.69	1.74	33.58	39.31
C.D. (5%)	4.73	4.45	0.15	0.13	2.83	1.77

Table 3. Effect of sowing dates and varieties on grain yield and H.I.

Treatments	Grain yield (q/ha)		H.I.	
	2000-2001	2001-2002	2000-2001	2001-2002
Sowing dates				
November 22	48.01	48.70	0.362	0.401
December 22	32.62	30.40	0.341	0.377
SE±	0.72	0.30	0.007	0.002
C.D. (5%)	4.32	1.79	NS	0.014
Varieties				
CPAN-3004	41.77	39.60	0.375	0.393
NIAW-34	38.60	38.00	0.356	0.414
PBW-343	48.65	43.72	0.375	0.417
PBW-373	37.45	38.65	0.328	0.417
RAJ-3077	40.83	38.49	0.362	0.370
RAJ-3765	44.71	42.45	0.390	0.395
UP-2003	34.18	36.59	0.301	0.380
UP-2338	48.17	43.75	0.383	0.414
UP-2382	42.86	40.87	0.362	0.399
UP-2425	45.49	46.40	0.379	0.422
WH-542	29.91	31.88	0.287	0.340
WH-896	31.21	34.49	0.330	0.337
C.D. (5%)	4.10	3.28	0.035	0.038

recorded with UP 2425 followed by NIAW-34 under both sowing dates. Higher 1000-grain weight of UP-2425 may be due to combined effect of lower number of grains per spike and higher grain weight per spike under both sowing dates. Highest number of grains per spike and lower grain weight may be the reason for lower 1000-grain weight in WH-542 and CPAN-3004.

Grain yield

December 22 sowing significantly reduced the grain yield which were 32.06 and 37.57 per cent during 2000-2001 and 2001-2002, respectively. On an average variety PBW-343 (48.65 q/ha) significantly out yielded from all the varieties except UP-2338, UP-2425 and Raj-3765 during 2000-2001. Whereas significantly higher grain yield was produced by UP-2425 (46.40 q/ha) than all the varieties during 2001-2002, but it was at par with UP-2338 (43.75 q) and PBW-343 (43.72 q/ha).

The lowest grain yield (29.91 and 31.88 q/ha) was produced by WH-542 and it was at par with WH-896. November 22 sown crops exhibited higher harvest index than December 22 sown crop. Variety Raj-3765 and WH-542 recorded highest and lowest harvest index, respectively during 2000-2001, whereas UP-2425 and WH-896 was the varieties, which exhibited highest and lowest harvest index, respectively during 2001-2002. It might be due to the fact that decreased partitioning of dry matter toward sink (grain) with delay in sowing. Rao (1986) and Hari Kumar (1989) also recorded significant reduction in harvest index in late sown crop. Singh and Uttam (1993); Rajput and Verma (1994).; Sanwal (1998) and Sandeep Kumar (1998) reported similar results in November sown crop. High grain yield of November 22 sown crop may collectively due to higher number of ear bearing shoots, grain number, grain weight per spike and 1000-grain weight from the crop sown on December 22. A positive and significant correlation was observed between number of spikes per unit area, 1000-grain weight by Joshi and Singh (1983); Lakita and Chaudhary (1984); Hossain *et al.* (1986) and Das *et al.* (1995).

In timely sown crops (November 22), PBW-343 recorded significantly highest grain yield over other varieties but at par with UP-2332 during 2000-2001 and UP-2338, UP-2425, UP-2382, Raj-3765 and CPAN-3004 during 2001-2002 (Table 4). Under late sown crop significantly highest grain yield was produced by UP-2425 during both the years except UP-2338, PBW-343, Raj-3765, UP-2382 and CPAN-

Table 4. Interaction effect of sowing dates and varieties on grain and H.I. of wheat

Varieties	Grain yield (q/ha)				H.I.			
	2000-2001		2001-2002		2000-2001		2001-2002	
	Nov. 22	Dec. 22	Nov. 22	Dec. 22	Nov. 22	Dec. 22	Nov. 22	Dec. 22
CPAN-3004	48.51	35.03	49.50	29.70	0.356	0.393	0.423	0.363
NIAW-34	43.94	33.25	47.60	28.40	0.344	0.348	0.420	0.407
PBW-343	59.72	37.58	53.63	33.80	0.404	0.345	0.433	0.400
PBW-373	44.98	29.92	47.97	29.33	0.339	0.316	0.403	0.430
RAJ-3077	46.70	34.95	47.97	29.00	0.360	0.364	0.380	0.360
RAJ-3765	51.67	37.75	51.77	33.13	0.409	0.370	0.407	0.383
UP-2003	41.41	26.94	47.30	25.87	0.321	0.281	0.407	0.353
UP-2338	58.32	38.01	52.63	34.87	0.388	0.378	0.420	0.407
UP-2382	49.58	36.13	49.67	32.07	0.390	0.333	0.407	0.390
UP-2425	52.00	38.98	52.43	40.37	0.397	0.360	0.407	0.437
WH-542	38.62	21.20	40.33	23.43	0.305	0.268	0.347	0.333
WH-896	40.69	21.75	43.80	25.17	0.341	0.318	0.377	0.297
	SEm±	CD (5%)	SEm±	CD (5%)	SEm±	CD (5%)	SEm±	CD (5%)
For comparing two varieties at same dates	2.03	5.79	1.63	4.63	0.017	0.018	0.019	0.054
For comparing two dates at same or different varieties	3.14	14.88	1.59	4.69	0.050	0.061	0.018	0.053

3004 during 2000-2001. Higher grain yield of PBW-343 was might be due to combined effect of ear bearing tillers, number of fertile spikelets per spike and grain weight per spike in November 22 sown crop during both the years. High grain yields of UP-2425 and UP-2338 in late sown condition may be attributed to higher number of spikes per unit area, higher grain weight per spike and high thousand-grain weight than other varieties in December 22 sowing, Raj-3765, followed by PBW-343 recorded highest harvest index than all the varieties in November 22 sown crop whereas, CPAN-3004 followed by UP-2338 exhibited highest harvest index in December 22 sown crops of 2000-2001. Variety PBW-343 followed by UP-2338 and UP-2425 followed by PBW-373 was the highest harvest index producing variety in November 22 and December 22 sown crops, respectively, during 2001-2002.

CONCLUSION

From the above experiment it was concluded that the normal sowing of wheat crop is better than late sowing. At normal sown condition (November 22) variety PBW-343 gave maximum yield but in case of late sown condition variety UP-2425 produced maximum yield and UP-2338 gave better results under both the condition.

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EFFECT OF PLANT GROWTH REGULATORS CCC AND NAA ON THE GROWTH AND YIELD OF SUMMER MUNGBEAN

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ABSTRACT

Increasing mungbean production can help in alleviating protein malnutrition in Asian countries, where calorie-protein malnutrition is wide spread. Being a short duration (60-90 days) crop its yields are generally low. Our results of a study made at the Indian Agricultural Research Institute, New Delhi during summer season of 1999 showed that 2 sprays of Naphthalene acetic acid (NAA) at 20 or 40 ppm, one at 30 days after sowing (DAS) and the second at flowering, significantly increased growth characters, yield attributes and grain and straw yield of summer mung. Application of cycocel (CCC) at 750 ppm reduced days to 50% flowering which indicates that it can enhance maturity in summer mung. CCC at 750 ppm also showed benefits in some growth characters and grain yield.

Key words : CCC, NAA and mungbean.

More and more people in the world are turning to a vegetarian diet. Grain legumes such as mungbean (*Vigna radiata* (L.) Wilczek) have therefore to play a pivotal role in human diet. It is more important for Asian countries, where more and more hungry and malnutritioned children are being added each year. Mungbean is of special importance because short duration 60-65 days varieties of this chip crop available.

Considerable research has been done in India on agronomic management including seed rate and spacing (Jeswani and Baldev, 1990; Tomar and Tiwari, 1991), fertilizer needs (Singh *et al.*, 1994), and water management (Prasad *et al.*, 1990). However, there have been very few studies on the effect of plant growth regulators (PGRs), which can play an important role in increasing its yield because poor production in this and other grain legumes is attributed to excessive vegetative growth, poor harvest index, flower and fruit shedding, low seed setting, disintegration and ineffectiveness of nodules in post-flowering period etc. (Summerfied, 1980). PGRs have been reported to increase yield either by making the plants photosynthetically more effective (Sinha and Ghidyal, 1973) or enhance flower buds and check their abscission (Murthy and Singh, 1983). Growth promoting PGRs such as NAA (α-napthalene acetic acid) are used for prevention of pre-harvest drop of fruits, increasing fruit set, increasing parthenocarpy and control of flowering.

Similarly series of physiological alterations have been reported due to growth retardants such as CCC that are associated with an optimized yield formation in various crops (Oshio and Izumi, 1986). Only a few studies are available on the effect of PGRs on mungbean. Shah and Prathapasenan (1991) reported that CCC at 1000 ppm increased the dry matter in mungbean by 14.3% and Kaul et al. (1976) reported that CCC treated plants retained more flowers and thus resulted in more pods plant^{-1}. Pawan and Bhamble (1989) reported an increased in yield of mungbean due to CCC at 100 ppm. Similarly, Kalita (1989) reported an increase in dry matter yield of mungbean by 10-13% due to application of 50 ppm NAA. Subbian and Chammy (1984) reported that application of 2 sprays of NAA at 20 or 40 ppm increased the number of flowers in mungbean and Kalita (1989) reported that application of NAA at 50 ppm significantly increased the grain yield of mungbean. Comparative studies on the effect of growth promoters and growth retardants on mungbean are not available. The present study was therefore taken up to study the effect of plant growth regulators NAA and CCC on the growth, yield attributes and yield of mungbean.

MATERIALS AND METHODS

A field experiment was conducted on a sandy clay loam soil of pH 7.7 (1:2.5 soil to water) and 0.45% organic C content in split-plot designs with 3 replications. The main plot treatments were 3 varieties of mungbean (Pusa Baisakhi, PS-16 and Asha), while the sub-plot treatments were 5 PGR treatments (control, 750 and 1500 ppm CCC, 20 and 40 ppm NAA). NAA or CCC application was made by spraying the solution of desired concentration twice, at 30 days after sowing and again at flowering stage. The volume of spray was 600 litres ha^{-1}. Pusa Baisakhi and PS-16 are short duration (60-65 days) varieties, while Asha is a long duration (90 days) one.

The experimental field was given a pre-sowing irrigation and when soil came to condition it was disced twice and levelled. Mungbean seeds were inoculated with Rhizobium culture obtained from the Division of Microbiology of the Institute (IARI) and sown in rows 25 cm apart on 4 May, 1999; the intra-row spacing was 15 cm. The varieties Pusa Baisakhi and PS-16 were harvested on 15 July, while Asha was harvested on 2 August 1999. The summer months of May and June are very hot (mean maximum temperature 41 ± 2°C) and no rains are received. The crop therefore received 3 irrigations at 21, 45 and 60 days after sowing. Operations were recorded on number of leaves, branches and pods plant^{-1}, days to 50% flowering and maturity, length of pods, 1000-grain weight and grain and straw yields.

RESULTS AND DISCUSSION

Growth and development characters

The data on leaves, branches and dry matter plant^{-1} at 60 days after sowing are in Table 1. Mungbean variety Asha had the highest number of leaves plant^{-1} significantly more than PS-16, but was at par with Pusa Baisakhi. Dry matter plant-1 was the most in Asha, significantly more than in Pusa Baisakhi and PS-16. Thus longer duration mungbean variety Asha had more vegetative growth than the short

Table 1. Effect of varieties and plant growth regulators on number of leaves, branches and dry matter (DM) of summer mungbean 60 days after sowing

Treatment	Leaves plant^{-1} (Nos.)	Branches plant^{-1} (Nos.)	DM plant^{-1} (g)
Variety			
Pusa Baisakhi	60.5	40.1	18.6
PS-16	47.5	31.1	17.8
Asha	71.5	27.7	21.9
SEm±	3.87	2.26	0.61
C.D. (p=0.05)	15.2	8.9	2.4
Plant growth regulator			
Control	57.2	28.7	17.1
CCC@750 ppm	59.5	32.9	19.6
CCC@1500 ppm	55.7	31.7	18.4
NAA@20 ppm	63.1	34.7	19.9
NAA @ 40 ppm	63.5	34.8	22.5
SEm±	1.99	1.2	0.75
C.D. (P=0.05)	5.8	3.5	2.2

duration varieties PS-16 and Pusa Baisakhi. As regards PGRs, application of NAA significantly increased the number of leaves and branches and dry matter plant^{-1} and in respect of dry matter, application of 40 ppm was significantly superior to 20 ppm. Application of CCC at lower rate (750 ppm) also significantly increased the number of branches plant^{-1} and in this respect was at par with NAA at 20 or 40 ppm. CCC at 1500 ppm had a growth retarding effect. Our results agree with those of Kalita (1989) and Shah and Prathapasenan (1991) who reported an increase in dry matter production in mungbean with the application of NAA and CCC, respectively.

Days to 50% flowering can be used as an index tohastening maturity. The interaction between varieties and PGRs was significant and therefore, the data are presented in interaction Table 2. There was no effect of CCC or NAAA on days to 50% flowering in Asha, while in Pusa Baisakhi and PS-16 application of CCC at 750 or 1500 ppm. reduced the days to 50% flowering by 3-4 days. CCC, therefore may be advantageously used for hastening maturity in mungbean. Although information on the effect of plant growth substances on days to 50% flowering in mungbean is not available Coyne (1969) reported an early induction of flowering in field bean due to CCC application.

Yield attributes

The data on the effect of CCC or NAA on yield attributes, namely, number of pods

Table 2. Interaction effect of varieties and plant growth regulators on days to 50% flowering of summer mungbean

Plant growth regulator	Variety			
	Pusa Baisakhi	PS-16	Asha	Mean
Control	47.0	47.7	68.7	54.5
CCC @ 750 ppm	43.0	43.0	66.7	50.9
CCC @ 1500 ppm	43.7	44.3	68.3	52.1
NAA @ 20 ppm	46.0	45.7	68.3	53.3
NAA @ 40 ppm	45.7	46.3	69.3	53.9
Mean	45.1	45.4	68.3	
	Variety	PGR	Variety × PGR	
SEm±	0.66	0.44	0.75	
C.D. (P=0.05)	2.62	1.3	2.2	

plant^{-1}, pod length, grains pod^{-1} and 1000-grain weights are in Table 3. As regards number of pods plant^{-1}, PS-16 and Pusa Baisakhi produced significantly more pods plant^{-1} than Asha. Application of CCC at 750 ppm or NAA at 20 or 40 ppm significantly increased the number of pods plant-1 over control. The interaction variety × PGRs was also significant and the data are in Table 4. These dat ashow that the effects of CCC and NAA were significant only in Pusa Baisakhi and PS-16 but not in Asha. A significant increase in pods plant-1 was due to increased number of branches and fruiting points, which lead to better utilization of sunlight. These results are in conformity with Hunje *et al.* (1995) in Cowpea.

Mungbean variety Asha produced significantly longer pods than Pusa Baisakhi and PS-16 and had significantly more grains pod^{-1} than PS-16. Application of CCC at 750 ppm and NAA at 20 or 40 ppm produced significantly more grains pod^{-1} where as NAA at 20 or 40 ppm significantly increased 1000-grain weight.

Grain, straw yield and harvest index

The data on grain and straw yield and harvest index are in Table 5. Mungbean varieties did nto differ significantly in respect of grain yield but Asha produced significantly more straw than Pusa Baisakhi and PS-16 and this led to the lowest harvest index in Asha, significantly lower than the other two varieties. Application of NAA at 40 ppm produced most grain, significantly more than application of CCC or NAA at 20 ppm, which in turn was significantly more than control. The increase in yield would be expected because these treatments had increased the number of pods plant^{-1} as explained earlier. Subbian and Chamy (1984) and Kalita (1989) also reported in increase in mungbean yield

Table 3. Effect of varieties and plant growth regulators on number of pods plant^{-1} pod length and number of grains pod^{-1} and 100-grain weight of summer mungbean

Treatment	Pods plant^{-1} (Nos.)	Pod length (cm)	Grains pod^{-1} (Nos.)	1000-grain weight (g)
Variety				
Pusa Baisakhi	19.7	5.7	7.0	26.1
PS-16	20.9	5.5	6.5	25.6
Asha	15.7	6.4	7.3	26.5
SEm±	0.52	0.02	0.13	0.37
C.D. (p=0.05)	2.0	0.1	0.5	NS
Plant growth regulator				
Control	15.7	5.8	6.6	24.5
CCC@750 ppm	19.3	5.8	7.0	26.2
CCC@1500 ppm	16.3	5.9	6.7	25.2
NAA@20 ppm	20.2	6.0	7.1	26.6
NAA @ 40 ppm	22.0	6.0	7.3	27.6
SEm±	1.08	0.08	0.15	0.73
C.D. (P=0.05)	3.1	NS	0.4	2.1

Table 4. Interaction effect of varieties and plant growth regulators on number of pods plant^{-1} of summer mungbean

Plant growth regulator	Variety			
	Pusa Baisakhi	PS-16	Asha	Mean
Control	16.5	17.7	13.3	15.8
CCC @ 750 ppm	20.1	22.0	15.9	19.3
CCC @ 1500 ppm	16.5	18.1	14.4	16.3
NAA @ 20 ppm	22.0	22.0	16.5	20.2
NAA @ 40 ppm	22.8	24.6	18.6	22.0
Mean	19.7	20.9	15.7	
	Variety	PGR	Variety × PGR	
SEm±	0.52	1.08	1.86	
C.D. (P=0.05)	2.0	3.1	5.4	

by the application of NAA.

The results of our study show that application of CCC at 750 ppm or NAA at 20 or 40 ppm can be advantageously employed for increasing the grain yield of summer mungbean.

Table 5. Effect of varieties and plant growth regulators on grain and straw yield and harvest index of summer mungbean

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Variety			
Pusa Baisakhi	0.94	3.31	22.2
PS-16	0.88	3.22	21.5
Asha	0.94	3.97	19.0
SEm±	0.05	0.13	0.60
C.D. (p=0.05)	NS	0.50	2.3
Plant growth regulator			
Control	0.82	2.92	22.0
CCC@750 ppm	0.93	3.34	21.8
CCC@1500 ppm	0.88	3.87	20.8
NAA@20 ppm	0.94	3.69	20.4
NAA @ 40 ppm	1.03	3.90	21.0
SEm±	0.03	0.17	0.67
C.D. (P=0.05)	0.08	0.51	NS

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CHANGES IN REDOX POTENTIAL, pH AND INORGANIC P TRANSFORMATIONS IN SUBMERGED RICE SOILS

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ABSTRACT

The inorganic P transformations, available P status and changes in Eh and pH values under submergence with water and glucose was studied in intensively rice grown soils representing from eight districts of Andhra Pradesh. The results showed that the reduction was faster in clay soils followed by clay loams and loams and it was found that the decrease in Eh attains the soils to neutrality. Submergence causes slight increase or decrease of some inorganic P fractions, while the addition of organic source (glucose) hastens the reduction process and enhances the mineralization of organic P and increases the available P status. Among all the P availability indices the traditional Olsen's method was found to be superior in submerged soils as it correlated significantly with yield and P uptake.

Key words : Inorganic P fractions, P availability indices, redox potential, critical limit.

Rice is grown under submerged conditions and the physico-chemical regime of waterlogged soils is quite different from upland soils. In waterlogged soils the behavior of P is remarkably different from that of upland soils. The chemistry of submerged soils indicates that the P availability increases on flooding. When soils are submerged, there is a sharp fall in the redox potential along with an increase or decrease of soil pH which in turn influences the P availability. Several instances have been quoted in which rice had not responded to P application even in soils of low P, while the irrigated dry crops responded (Mandal, 1979). Knowledge of transformation of various inorganic P fractions and available P under submergence is necessary for better appreciation and adjustment of fertilizer recommendations. The present investigation was undertaken to study the effect of submergence or changes in redox potential, pH and inorganic P transformations and to evaluate available P status in submerged rice soils so as to adjust the fertilizer recommendations.

MATERIALS AND METHODS

Soils

Thirty-two bulk soil samples (0.3m) were collected from rice growing soils (rice-rice cropping sequence) from eight districts of Andhra Pradesh, India belongs to Alfisols, Inceptisols, Entisols and Vertisols. The soils had a wide range of texture (sandy clay loam to clay), neutral to slightly alkaline (pH 6.35 – 8.22), non saline (0.14 –2.23 dS m^{-1}), low to high in organic C (0.46 – 1.17%), low to medium in available N (220 – 418 kg ha^{-1}) and P_2O_5 (19.2 – 42.8 kg ha^{-1}) and medium to high in available K_2O (137 – 447 kg ha^{-1}).

Greenhouse study

Three kilograms of each processed soil was potted, soaked with water and kept under submergence. A uniform dose of N @ 150 kg ha^{-1} in the form of urea in three equal doses at basal, 15 days after transplanting (DAT) and 30 DAT, K @ 50 kg K_2O ha^{-1} in the form of KCI and P @ 0 and 100 kg P_2O_5 ha^{-1} in the form of single super phosphate were applied at basal. Each treatment was replicated thrice. All the fertilizers were applied in solution form and mixed thoroughly with the soil and flooded to a depth of 4.0 cm above the soil surface. Rice (cv Tellahamsa) seedlings of 21 days old were transplanted at two per hill and three hills per pot at equal spacing. The crop was harvested at 60 DAT, washed thoroughly, oven dried and dry matter yield was recorded. Plant samples were ground, digested with diacid mixture (HNO_3 – $HClO_4$, 7:3) and P was determined by vanadomolybdophosphoric acid yellow colour method (Jackson, 1973).

Submergence studies

Soil samples (200 g each) were taken into the plastic containers, submerged with water and maintained at 2.5 cm level above the soil surface so as to simulate puddled conditions. To hasten the reduced conditions provided readily available energy source in the form of glucose solution @ 0.5 and 1.0%. The samples were stored in cool and dark cupboard. In other set, only water was added to the soil samples. Water content in the plastic containers was kept constant throughout the incubation period by periodic additions of distilled water to replenish the deficient water. The study was done with duplicates.

The Eh was measured by using a calomel electrode and a platinum electrode in a digital pH meter at 0, 7, 14, 21, 28, 35, 42, 49, 56, 63 and 70th day after incubation under submergence with water (SW), while it was measured at 0, 7, 14 and 21 days after incubation under submergene with water and glucose (SWG). Soil pH also measured simultaneously after the measurement of Eh in the respective soils using combined glass and reference electrodes in digital pH meter at the end of 70th and 21st day after incubation under SW and SWG, respectively. The wet soil samples were drawn at the end of 70th and 21st day under SW and SWG (1%), respectively and inorganic P fractions and available P was determined. Moisture correction was made before soil sampling.

Phosphorus availability indices

Inorganic P fractions (Fe-P, Al-P, Ca-P, saloid-P and reductant soluble-P) in the submerged soils were determined sequentially (Jackson, 1973). The available P content was determined by using four reagents viz., 0.5 M $NaHCO_3$, pH 8.5 (Olsen et al., 1954), 0.5 N $NaHCO_3$ + 0.01 M EDTA, pH 8.5 (Ananthanarayana et al., 1989), 0.5 M NH_4HCO_3, pH 7.8 (Datta and Khera, 1969) and 1.0 M NH_4HCO_3 + 0.005 M DTPA, pH 7.6 (Soltanpour and Schwab, 1977).

Simple linear correlation coefficients between P availability indices and plant growth parameters were computed. Critical limit of P was derived by the method of Cate and Nelson (1965).

RESULTS AND DISCUSSION

Response of phosphorus

The results in Table 1 revealed that the dry matter yield varied from 6.2 to 21.0 g pot^{-1} with a mean of 14.0 g pot^{-1}. Application of phosphorus showed a wide variation in yield response (7.0 to 60.0%), indicating that the crop response is dependent on soil type. Lower response of rice even in P deficient soils was observed, which might be due to increase in available P content with submergence of the soil meets the P requirement of rice. An increase of 64 per cent in P uptake by rice was observed due to application of 100 kg P_2O_5 ha^{-1}. The response of rice in terms of P uptake varied from 33 to 99 per cent with a mean uptake response of 64 per cent. It was noticed that the P deficient soils showed greater response to the applied P than the soils having sufficient range of available P.

Changes in redox potential under submergence

The redox potential at '0' (prior to submergence) and at the end of 7, 14, 21, 28, 35, 42, 49, 56, 63, 70 days after submergence with water (SW) was found

Table 1. Effect of phosphorus on dry matter yield and P uptake by rice

Location/ District	No. of samples	Dry matter yield (g pot^{-1}) P_0	P_{100}	Mean	P uptake (mg pot^{-1}) P_0	P_{100}	Mean
West Godavari	6	6.2-15.6 (12.2)	14.2-21.0 (16.0)	11.7-18.3 (14.1)	8.0-13.6 (10.5)	15.8-23.6 (18.1)	11.9-18.6 (14.3)
East Godvari	5	8.5-16.0 (13.0)	10.1-18.9 (15.0)	9.3-17.5 (14.0)	6.7-12.9 (11.0)	11.1-21.1 (16.6)	8.9-17.0 (13.8)
Krishna	3	7.3-13.8 (9.9)	10.8-15.9 (12.6)	9.2-14.9 (11.2)	6.5-11.1 (8.2)	12.5-17.8 (14.4)	9.7-14.5 (11.3)
Guntur	3	11.0-13.1 (12.0)	13.6-15.6 (14.2)	12.3-14.3 (13.1)	8.8-10.9 (9.7)	14.8-16.8 (15.6)	11.8-13.8 (12.7)
Srikakulam	5	11.5-15.4 (13.6)	15.2-18.7 (16.8)	13.7-17.1 (15.2)	9.9-12.5 (11.0)	15.8-20.7 (18.2)	12.8-16.6 (14.6)
Rangareddy	3	11.0-16.2 (14.2)	14.9-19.4 (17.7)	13.0-17.4 (15.9)	9.2-12.6 (11.4)	15.1-21.7 (19.0)	12.2-17.1 (15.2)
Nalgonda	4	8.4-13.2 (11.3)	10.3-15.8 (13.4)	9.4-14.5 (12.3)	7.1-10.4 (9.3)	11.6-16.0 (14.4)	9.3-13.2 (11.8)
Nellore	3	9.8-16.5 (14.2)	10.6-20.4 (17.0)	10.2-18.4 (15.6)	7.9-12.7 (11.1)	12.1-22.5 (18.6)	10.0-17.6 (14.8)
Mean		12.6	15.4	14.0	10.4	17.0	13.7
CD (P=0.05) Soils				2.52			2.49
CD (P=0/05) Phosphorus				0.63			0.62
CD (P=0/05) Interaction (S×P)				3.57			3.52

Note : Parantheses indicate the mean values to be 261, 154, 75, 22, -37, -102, -154, -165, -152, -145 and -144 mV. However, the mean Eh values with the addition of 5 mg^{-1} glucose (0.5 %) at the beginning of incubation and at 7, 14 and 21 days after submergence were found to be 257, 68, -46 and -143 mV, while the values for 1.0% glucose submergence were 250, 25, -113 and -130 mV at the same intervals. The fall of redox in clay, clay loam and loamy soils were depicted in Fig. 1, 2 and 3, respectively. The redox become negative (-37 mV) at 28 days after submergence and attained lowest value (-165 mV) by 49 days after submergence and remained almost constant upto 70 days after submergence. The reduction of Eh values was more with glucose added submergence than with pure water. Addition of easily decomposable organic compound (glucose) accelerated the reduction process and peak reduction was attained by 21 days after submergence. The Eh changes were more dependent on soil type, organic matter status, Fe and Mn content, pH, temperature and bacterial potentials (Ghildyal, 1976). On flooding, the anaerobic organisms utilize the oxidized soil components as electron acceptors resulting in reduction of the compounds of organic matter, which serves as an electron donor and accelerates the reduction process. These results are in corroborative with findings of Mandal (1961).

Alluvial soils of Krishna - Godavari zone suffered more redox than clay loams and loams of other regions of Andhra Pradesh. Maximum reduction of Eh (-181 mV) was recorded at the end of 49 days after submergence in clay soils (13), while it was -161 mV in clay loams (14) and -140 mV in loamy soils (5) at the same period. The results indicating that the fall of redox was more faster in clay soils as compared with clay loams and loams which might be due to presence of more organic matter, clay content, Fe and Mn content (Ghildyal, 1976).

The decrease of Eh was faster with the increased levels of glucose addition. The mean Eh values with the addition of 0.5% glucose at 0, 7, 14 and 21 days after submergence were found to be 257, 68, -46 and -143 mV, while the Eh values for 1.0% glucose submergence were found to be 250, 25, -113 and -130 mV at the same intervals. Addition of increased levels of organic source (glucose) resulted in sharp fall of Eh with time of submergence, which was proportional to the soil dissolved organic carbon (Amer et al., 1991).

Changes in pH under submergence

Submergence of the soils showed slight changes in the pH of soils ranged from 6.72 to 7.52 from the original values of 6.35 to 8.22, indicating that the soils in slightly acidic and alkaline ranges attained to neutrality (pH 6.5 to 8.22, indicating that the soils in slightly acidic and alkaline ranges attained to neutrality (pH 6.5-7.5) due to submergence. However, the changes in pH was from 6.59 to 7.41 and 6.61 to 7.35, respectively under 0.5 and 1.0% glucose submergence. The Eh changes were also accompanied by changes in pH under submergence and found that as the decrease in Eh attains the soils to neutrality. These results are in accordance with the findings of Amer et al. (1991). Increased levels of glucose addition decreased the pH in all soils as compared with pure water submergence. Since the soils of present study are almost neutral to alkaline, there was a fall of pH, which was mainly attributed to the production of CO_2 and organic acids at the very early stage of decomposition of organic matter by the consumption of dissolved O_2 in the soil by aerobic microorganisms (Ghildyal, 1976). The rise in pH of some soils is due to reduction of Fe_3^+ and Mn_4^+ compounds and release of OH- ions, production of NH_3 and CO_2 (Mandal, 1964 and Amer et al., 1991).

Transformation of inorganic P fractions under submergence

Distribution of different inorganic P fractions in the soils under submergence with water (SW) and submergence with water and glucose (SWG) was presented in Table 2 and Fig. 4. The Fe-P content in submerged soils under SWG showed an increase of 13% as compared to air dry soils, ranged from 26.8 to 47.8 mg kg^{-1} (mean of 37.7 mg kg^{-1}), while the increase of Fe-P under SW was found to be 20% with a range of 28.9 to 50.3 mg kg^{-1} (mean of 40.1 mg kg^{-1}). The Al-P content in these soils under SWG varied from 25.7 to 47.8 mg kg^{-1} with a mean of 36.8 mg kg^{-1}, while the occurrence of Al-P under SW was 27.6 to 49.8 mg kg^{-1} (mean of 39.0 mg kg^{-1}). The Ca-P varied from 63.1 to 145.7 mg kg^{-1} (mean of 87.2 mg kg^{-1}) and 52.0 to 144.0 mg kg^{-1} (mean of 85.2 mg kg^{-1}) under SW and SWG, respectively. Of all the P fractions, S-P was the lowest and ranged from 3.4 to 8.9 mg kg^{-1} and 1.9 to 8.3 mg kg^{-1} under SWG and SW, respectively. In line with other P fractions, RS-P showed an increase of 14 per cent as compared to air dry soils and ranged from 21.7 to 46.1 mg kg^{-1} (mean of 31.1 mg kg^{-1}) under SWG and the increase was 21 per cent under SW with a range of 22.6 to 48.2 mg kg^{-1}.

The contribution of different inorganic P fractions from total P in the soils as a sequel of submergence was found to be in the order of

Air dry soil

Ca-P (33%) > Al-P (16%) > Fe-P (14%) > RS-P (11.5%) > S-P (2%)

Submergence with water

Ca-P (37%) > Fe-P (17%) > Al-P (16%) > RS-P (14%) > S-P (2%)

Submergence with water and glucose

Ca-P (36%) > Fe-P (16%) > Al-P (15%) > RS-P (13%) > S-P (2.5%)

The sequence of occurrence of different P fractions in soils was unaffected due to submergence, however there was an increase or decrease of some inorganic P fractions was observed. Addition of an organic source (glucose) also showed no change in the order of P fractions in submerged soils. These results are in accordance with the findings of Patel et al., (1992). There was a higher increase in Fe-P and RS-P (20-21%) and Ca-P (11%), whereas little change in Al-P and S-P fractions was observed under submergence with glucose. The increase of Fe-P in submerged soils might be due to transformation of ferric phosphate to more soluble ferrous phosphate caused by an increase in pH due to submergence. Increase of Ca-P in submerged soils is due to conversion of insoluble tricalcium phosphate to more soluble mono and dicalcium phosphate. The increase of RS-P on waterlogging might be due to an increase in pH, which increases the rate of mineralization

Table 2. Inorganic P fractions (mg kg^{-1}) in rice soils under submergence

Soil	Glucose (1.0%)					Water				
No.	Fe-P	Al-P	Ca-P	S-P	RS-P	Fe-P	Al-P	Ca-P	S-P	RS-P
1	37.6	30.4	73.8	5.3	29.2	40.9	32.6	75.2	3.6	30.9
2	36.9	31.8	70.7	6.6	28.6	39.6	33.2	72.6	5.6	30.6
3	34.3	44.9	66.0	5.5	28.2	35.9	48.3	67.9	4.3	29.6
4	46.2	43.6	80.8	8.7	46.1	48.4	46.4	83.4	8.3	48.2
5	30.8	261	65.3	42	28.8	32.2	28.2	67.5	3.0	30.4
6	42.9	25.7	144.0	5.7	38.2	44.7	27.6	145.7	4.6	40.1
7	42.4	34.3	96.2	8.9	30.6	44.3	37.9	98.2	7.9	32.2
8	43.6	43.0	114.1	6.8	33.7	46.9	44.2	117.3	3.6	35.1
9	47.8	38.2	131.0	8.4	39.1	50.3	42.3	133.2	6.6	42.8
10	46.4	45.8	138.8	7.2	39.5	49.1	49.8	140.4	5.0	43.4
11	38.6	40.2	133.4	8.1	31.4	40.7	41.9	136.7	7.1	33.6
12	38.5	41.8	110.2	7.4	31.0	40.5	46.7	112.5	6.3	32.9
13	33.4	33.6	61.8	3.4	28.8	36.3	35.4	63.3	2.7	30.5
14	42.7	43.9	124.6	5.6	35.4	47.6	45.7	127.7	3.8	38.8
15	39.2	34.4	115.4	4.3	24.1	42.2	36.8	117.6	2.2	27.3
16	43.0	31.9	69.2	7.1	35.7	44.7	33.6	71.4	5.9	37.6
17	29.0	47.8	66.6	5.9	26.8	32.4	40.9	68.2	4.4	28.7
18	31.4	41.7	52.0	3.9	28.6	32.2	34.2	54.4	3.3	30.2
19	28.2	35.5	61.4	6.6	25.8	28.9	47.9	63.1	4.6	27.5
20	27.2	39.6	69.4	5.1	21.7	29.4	43.4	72.3	4.1	22.6
21	38.6	38.8	63.2	3.6	31.6	43.3	41.3	64.6	1.9	33.7
22	36.9	34.7	71.8	4.2	31.0	42.2	38.5	73.9	2.9	32.9
23	44.7	35.2	97.2	5.0	38.2	45.1	38.3	99.2	3.8	41.6
24	30.1	27.5	67.4	4.3	24.0	32.7	30.8	68.5	3.2	26.3
25	26.8	26.7	65.2	4.6	23.96	29.8	29.4	67.1	3.5	25.8
26	32.9	32.2	52.0	4.8	29.1	34.3	36.9	54.2	3.2	32.1
27	42.1	29.9	74.4	5.1	26.0	43.2	32.2	76.3	3.8	27.1
28	33.6	38.2	70.8	4.6	25.2	35.6	35.5	72.9	3.36	26.4
29	37.5	37.6	72.0	6.4	29.7	39.7	39.4	73.4	4.9	31.3
30	47.2	44.8	110.4	8.1	38.9	48.8	47.9	112.3	5.8	40.3
31	37.6	38.2	63.0	7.5	32.0	39.2	40.7	64.2	6.1	34.2
32	38.1	38.3	73.2	7.0	33.2	41.1	39.2	75.4	5.4	35.6
Mean	37.7	36.8	85.2	5.9	31.1	40.1	39.0	87.2	4.5	33.1

and decreased sorption of organic P compounds by hydrous oxides. However, a slight decrease in Al-P content of alluvial soils, was observed under submergence with water, which might be due to hydrolysis of Al oxides and hydroxides, similar to the findings of Mandal (1964).

Phosphorus availability indices

The available P as extracted in the soils at peak submergence i.e. 70 and 21 days after submergence under SW and SWG, respectively was presented in Table 3. It was observed that the Olsen's extractable P ranged from 25.0 to 48.6 kg P_2O_5 ha^{-1} (mean of 35.0 kg P_2O_5 ha^{-1}) under SWG, while it was 24.6 to 47.4 kg P_2O_5 ha^{-1} (mean of 34.1 kg P_2O_5 ha^{-1}) under SW. An increase of 19 and 16 per cent of extractable P was noticed under SWG and SW, respectively as compared with the dry soil extraction. The increase in the extractable P in submerged soils by different methods in comparison with air dry soils was in the order of

Submergence with water

AB-P (17%) > Olsen's - P (16%) > AB-DTPA-P (11%) > Modified Olsen's-P (4%).

Submergence with water and glucose

AB-P(24%) > Olsen's-P (19%) > AB-DTPA-P (16%) > Modified Olsen's-P (4%).

The available P extracted by modified Olsen's reagent recorded highest values than the other methods with a range of 25.3 to 52.2 kg P_2O_5 ha^{-1} (mean of 26.9 kg P_2O_5 ha^{-1}) under SWG, while it was ranged from 24.4 to 49.4 kg P_2O_5 ha^{-1} (mean of 35.3 kg P_2O_5 ha^{-1}) under SW. The P extraction is more in modified Olsen's method in submerged soils than Olsen's method was due to inclusion of EDTA in the Olsen's reagent, which might have partly complexes Al and Fe thus releasing some P (Alexander and Robertson, 1972). It was observed that ammonium bicarbonate extractable P (AB-P) showed lowest values ranged from 21.1 to 36.5 kg P_2O_5 ha^{-1} and 19.5 to 34.7 kg P_2O_5 ha^{-1} under SWG and SW, respectively. However, the extractable P by ammonium bicarbonate - DTPA (AB-DTPA-P) recorded highest values as compared to AB-P, which was ranged from 20.3 to 37.8 kg P_2O_5 ha^{-1} (mean of 27.9 kg P_2O_5 ha^{-1}) and 19.5 to 35.5 kg P_2O_5 ha^{-1} (mean of 26.8 kg P_2O_5 ha^{-1}) under SWG and SW, respectively. Inclusion of DTPA in ammonium bicarbonate (1M NH_4HCO_3 + 0.005 M DTPA) extracted more P, due to chelating action of DTPA with Ca, Fe and Al (Chandrasekhara Rao and Bajaj, 1994).

The increase in available P under submergence as compared to air dry soils might be due to relative distribution of different inorganic P forms, free iron oxide, organic matter status of the soil, reduction of insoluble $FePO_4$ to more soluble $Fe_3(PO_4)^2$, hydrolysis of ferric and aluminum phosphate and increase of their solubility caused by increase in pH of acid soils, release of P from organic matter and increase in solubility of Ca-P, which leads to differential P response in submerged rice soils (Patel et al., 1992). However, addition of easily decomposable organic source (glucose) increased the amount of P extraction more than the soils under water submergence, which might be due to more mineralization of organic P and enhanced reduction causing more inorganic P fractions to solubilize (Mira Das et al., 1993).

Table 3. Available P (kg P_2O_5 ha^{-1}) extracted by different methods under submergence

Soil	Water and glucose submergence				Pure water submergence			
No.	Olsen's-P	Modified Olsen's-P	AB-P	AB-DTPA -P	Olsen's-P	Modified Olsen's-P	AB-P	AB-DTPA -P
1	32.3	34.3	23.0	27.0	31.0	31.6	21.3	26.1
2	30.9	33.4	22.4	25.1	31.6	33.1	20.0	24.8
3	30.0	31.3	21.6	24.3	30.2	29.6	19.5	24.5
4	39.8	42.3	31.1	33.3	40.2	41.7	28.0	31.5
5	25.9	26.8	23.0	22.2	24.6	25.3	18.7	21.3
6	29.4	30.4	28.4	27.8	30.0	31.0	26.7	27.2
7	33.9	36.4	27.0	29.7	34.5	36.4	26.4	28.0
8	43.6	46.2	29.7	31.1	42.5	44.5	27.5	30.7
9	48.6	52.2	36.5	37.8	47.4	49.4	34.7	35.5
10	45.6	49.2	35.1	35.1	43.1	46.0	32.8	33.3
11	38.3	40.2	31.1	31.1	36.8	38.2	26.7	28.0
12	36.8	38.1	27.8	28.9	35.1	35.9	24.8	27.5
13	28.0	29.2	23.8	21.6	27.3	26.7	21.3	21.3
14	40.6	43.2	29.2	32.4	38.8	40.2	28.0	32.0
15	37.4	38.7	26.5	29.7	35.9	36.8	25.3	28.8
16	38.9	40.2	27.8	29.2	37.4	41.7	26.7	27.2
17	33.3	35.2	24.3	25.7	32.2	33.9	22.7	24.0
18	25.0	25.3	20.3	20.3	25.9	25.9	19.5	19.5
19	35.9	38.1	30.5	30.5	34.5	35.9	29.3	29.3
20	27.1	27.7	23.0	21.6	27.3	26.7	22.1	20.8
21	35.9	38.7	24.3	27.6	36.8	37.9	23.2	27.5
22	31.8	33.7	23.0	26.5	32.2	36.1	22.5	26.1
23	41.2	43.2	31.1	33.8	37.9	38.8	30.1	32.5
24	32.3	32.8	27.0	27.0	30.2	31.6	26.1	27.2
25	31.8	31.9	26.5	25.7	27.3	30.2	24.0	25.3
26	28.9	28.3	21.1	21.6	28.2	24.4	21.3	20.0
27	35.3	36.7	23.8	25.7	34.5	35.9	23.5	24.5
28	33.9	35.8	22.4	23.8	33.9	35.4	21.3	22.7
29	38.3	39.6	27.8	28.4	35.9	38.8	25.3	26.7
30	43.6	47.7	33.0	33.0	42.5	45.4	32.0	32.0
31	36.2	38.1	27.8	28.4	34.5	35.9	25.9	28.0
32	30.9	34.3	25.7	25.7	29.3	31.0	24.0	24.0
Mean	35.0	36.9	26.7	27.9	34.1	35.3	25.1	26.8

Relationship of P availability indices with plant growth parameters

Relationship between available P as extracted by different methods in submerged soils and biological indices was presented in Table 4. Olsen's extractable P showed highly significant and positive relationship with Bray's per cent yield under SW (r=0.82**) and SWG (r=0.83**) followed by modified Olsen's-P (r=0.81** and 0.82** under SW and SWG, respectively). It was observed that the Olsen's-P had highest and significant relationship than the other availability indices with Bray's per cent uptake (r=0.57** and 0.53**) and control P uptake (r=0.46** and 0.48**) under SW and SWG, respectively, indicating its superiority.

Critical limit of available P in submerged soils

A scatter diagram drawn by plotting Olsen's extractable P Vs relative yield and relative P uptake suggests that critical level of Olsen's-P is 33.5 kg P_2O_5 ha^{-1}. Results of the present study thus indicate that rice soils of Andhra Pradesh showed significant response to the applied P if the soils having available P lower than the critical limit of 33.5 kg P_2O_5 ha^{-1} (Fig. 5) under submergence.

The traditional Olsen's method was found to be superior in rice soils of Andhra Pradesh than other methods because it is simple, reliable, correlating significantly with yield and P uptake by rice and it can be suitable for neutral to alkaline soils. The increase in available P under submergence causes no response of rice to the applied P, however the submergence effect was not taken into consideration in Soils Testing Laboratories for making fertilizer recommendations. Determining the critical limit for P fertilization considering the submergence effect is more appropriate to obtain highest response to the applied P and to enhance the fertilizer use efficiency.

Table 4. Linear correlation matric (r) between P availability indices in submerged soils and plant growth parameters

P availability method	Submergence with water			Submergence with water and glucose		
	Bray's %Y	Bray's % U	P uptake (P_0)	Bray's %Y	Bray's % U	P uptake (P_0)
Olsen's-P	0.82**	0.57**	0.46**	0.83**	0.53**	0.48**
Modified Olsen's-P	0.81**	0.54**	0.38*	0.82**	0.53**	0.45**
AB-P	0.81**	0.50**	0.22	0.72**	0.39*	0.23
AB-DTPA-P	0.74**	0.45**	0.35*	0.78**	0.50**	0.28

* & ** Significant at 5 and 1 percent level, respectively

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ECONOMIC IMPACT OF SUB SURFACE DRAINAGE ON RICE AND PEARLMILLET PRODUCTION : A CASE STUDY OF HARYANA OPERATIONAL PILOT PROJECT

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ABSTRACT

Rice and pearl millet were the major foodgrain crops of the area selected under Haryana Operational Pilot Project in block Gohana of Sonipat district. The operational size of the holdings 11% medium salt affected. The annual cost of drainage system estimated of Rs. 2666.66 per ha. The operational cost of Basmati rice cultivated with drainage and without drainage systems was the same but on the basis of costs C1 and C2, it was 11 and 6 per cent more for the drainage system. The yield of rice was 17 per cent more in drained situation as compared to the non-drained fields whereas the net income was as high as 61% for the drained plots over the non-drained on cost A1 and 34% on cost C1. The cost and return of pearl millet was slightly higher under drainage system as compared to those of the non-drained crop. The regression analysis explained remarkable influence of fertilizer and human labour on return of pearl millet. The regression analysis explained remarkable influence of fertilizer and human labour on return of the rice grown under drainage system.

Key words : Economic impact, surface drainage, rice, pearlmillet.

Several factors make drainage a necessity on prolonged waterlogged areas for efficient agricultural production. These factors include slow soil permeability, flat or depressional topography, restrictive geologic layers underlying the soil profile and excess precipitation. Texture affects permeability or the ability of soils to drain water. Slowly permeable soils contain relatively large percentage of clay and silt-sized particles which hold water well but do not drain well. Coarse soils contain a large percentage of sand-sized particles which hold water well but do not drain well. Coarse soils contain a large percentage of sand-sized particles and tend to hold less water but drain well. The permeability of the soil is affected by soil structure as well. A granular soil structure promotes the movement of water through soil while a massive structure with little or no granular components decreases the movement of water. Compaction on agricultural and from the use of farm machinery and tools on wet soils also destroys soil structure and creates a layer that restricts the downward movement of water.

Drainage continues to be a vital and necessary component of agricultural production systems. Excess water in root one in injurious to plant growth. Crop yields are drastically reduced on poorly drained soils and in water logging situations. The waterlogging situation has been resulted soil salinity in many parts of the country. Therefore, artificial drainage is essential on poorly drained agricultural fields and regarded as an important water management practice of efficient crop production systems. The productivity of existing agricultural ilands can only be maintained and enhanced if proper drainage measures are undertaken in the excess water affected areas. In general, drainage increases crop yield, farm income and land value, on one hand and reducing income disparity in the society, on the other. Agricultural land drainage usually consists of surface or sub-surface systems or a combination of both. Surface drainage is often achieved by land leveling and smoothing to remove isolated depressions but sub-surface drainage requires lot of funds and resources.

The Central Soil Salinity Research Institute (CSSRI) Karnal has been carried out several studies on sub-surface drainage to test the developed technology on a large scale, covering about 550 ha agricultural land by its own resources and more than 2000 ha area under two pilot projects in collaboration with the other national and international agencies in Haryana. It is reported that there was a considerable increase in crop yield, shift in cropping pattern towards more remunerative crops and remarkable increase in cropping intensity of the area covered under the sub-surface drainage system. The present study was an attempt to assess the impact of sub-surface drainage technology on crop production at the farmer's field. The specific objectives of the study were to (i) estimate economics of Basmati rice and pearl millet (Hybrid) crops grown with and without drainage systems, (ii) compare economic performance of the crops under two production situations, and (iii) estimate efficiency of the production inputs for crop production under drainage and non-drainage situations.

MATERIALS AND METHODS

The present study was undertaken to assess the impact of sub-surface drainage (SSD) on crop Project (HOPP) was initiated by the CSSRI in 1997. The project covered an area of 1236 ha spread in four villages namely Rewara, Moi, Bali and Katwal. All the four villages were selected for the investigation. To compare economics of the crops, another neighboring village Lath was also chosen as control village where crop production took place without drainage. The total number of households selected was 116, out of which 89 were from SSD villages, i.e., Rewara, Moi, Bali and Katwal and 27 from non-SSD village Lath. Considering the fact that the Kharif crops are affecting severely from the waterlogging problem, only those crops were taken for the impact assessment, which were grown during Kharif season. Two crops namely Basmati rice and Pearl millet (Hybrid) were chosen purposely for detailed economic analysis, as these were the only food-grain crops cultivated in the SSD sample plots.

The physical input and output coefficients of the crops along with their prevalent market prices were recorded from the farmers on pre-structured questionnaires and schedules. The data tabulated at first and analyzed thereafter to present finally in the form of tables for interpretation of the inferences. Cost concept 'A1', 'A2', 'B1', 'B2', 'C1' and 'C2' was adopted to highlight economics of the crop production. Cost 'A1' included all the actual expenses made for crop production in cash and kind which covered value of hired human labour, bullock labour (hire and owned), machine charges (hired and owned), seed (purchased and farm produced), manure (purchased and farm produced), fertilizers, plant protection chemicals, weed cides, irrigation charges, land revenue and other taxes, depreciation on farm buildings, farm machinery and other fixed assets, interest on working capital and miscellaneous charges paid by the farmer on account of crop production such as payment made to artisans, blacksmith, carpenter etc. Cost 'A2' included cost 'A1' plus rent paid for leased-in land. Cost 'B1' included cost 'A2' plus interest on the value of fixed assets (excluding land). Cost 'B2' covered cost 'B1' plus rental value of owned land (minus revenue). Cost 'C1' included cost 'B1' plus imputed value of family labour and cost 'C2' included cost 'C2' included cost 'B2' plus imputed value of family labour. The hired and family labour cost is estimated on the basis of average market rates prevalent for hiring labour in the locality whereas cost on machinery is charged as per existing hiring rates of these machines in the area for various agricultural operations. Interest rate for working capital is considered at the rate of 12 per cent per annum whereas in case of the fixed capital, it charged 10 per cent per year. The rental value of owned land is charged at the rate of Rs. 20,000 per ha per year as per prevalent rate in the area and estimated of Rs. 10,000 per crop season. The input-output data pertaining to the cultivation of Basmati rice and pearl millet (Hybrid) were collected during the year 2000.

Beside the common statistical analytical tools, the linear production function analysis was made, using least square technique, to estimate resource efficiency for the selected crops grown under SSD and Non-SSD situations. Before undertakiing the regression analysis, zero order matrixes were estimated for both the systems which explained no multi-colinearity amongst the variables (APPENDIX-I). The following form of the linear multiple production function model was adopted to explain impact of drainage system on input use efficiency, as it found the best fit.

$$Y = a + b1\ X1 + b2\ X2 + b3\ X3 + b4\ X4 + b5\ X5$$

Where;

Y = Gross return received from Basmati rice in Rs/ha,

X1 = Human labour cost in Rs./ha,

X2 = Cost of machine power in Rs./ha

X3 = Cost of fertilizer in Rs./ha

X4 = Cost of weedcides in Rs./ha

X5 = Cost of weedcides in Rs./ha

b1.....b5 = Regression coefficients of the respective variables, and

a = Intercept

RESULTS AND DISCUSSION

The net operated area of the sample holdings was ranged from 2.54 ha in Moi to 8.81 ha in Bali village with an overall

Appendix - I

Zero order matrixes of the five input variables considered for the analysis

Variables (X)	Human labour (Rs./ha) X_1	Machine power (Rs./ha) X_2	Fertilizers (Rs./ha) X_3	Irrigation (Rs./ha) X_4	Weedicides (Rs./ha) X_5
With Drainage System					
Human labour (Rs./ha) X_1	1.000	0.464	0.488	0.136	0.420
Machine power (Rs./ha) X_2		1.000	0.266	0.448	0.243
Fertilizers (Rs./ha) X_3			1.000	-0.001	0.459
Irrigation (Rs./ha) X_4				1.000	0.017
Weedicides (Rs./ha) X_5					1.000
Without Drainage System					
Human labour (Rs./ha) X_1	1.000	0.253	-0.154	0.146	0.175
Machine power (Rs./ha) X_2		1.000	-0.035	0.047	0.656
Fertilizers (Rs./ha) X_3			1.000	-0.001	-0.035
Irrigation (Rs./ha) X_4				1.000	0.034
Weedicides (Rs./ha) X_5					1.000

Note : None of the value found statistically significant

average of 4.75 ha per farm. The owned cultivated land on an average was 4.25 ha per farm whereas the area leased from other farmers on rental basis was 0.5 ha. The area under SSD ranged from 1.39 ha in Moi to 3.22 ha per farm in Rewara village with an overall average of 2.35 ha per farm. The details of holding fragmentation, type of soil and source of irrigation, given in Table 1 depicted that operational holdings were fragmented in to, on an average, 2.82 plots per farm which ranged fro 2 plots in Lath to about 4 plots per farm in Moi village. The average size of the plots was 1.54 ha which was the largest in Bali being 2.41 ha and the smallest in Moi village (0.63 ha). The larger size of the plots favours mechanization of the farm and economize labour and machine-use in performing various farm operations.

The soil type analysis revealed that there were three types of the soil in the selected villages normal, marginally salt affected and medium salt affected. On an average about 53% soils were normal, 36% marginally salt affected and 11% medium salt affected. About 95% area of Bali and Moi villages was normal whereas nearly 64% area in Katwal, 61% in Rewara and 50% soils in Lath village were marginally salt affected. The largest area under medium salt affected

Table 1. Operational holdings, soils and irrigation details of the selected farms

Particulars	Villages				
	Rewara	Lath	Moi	Bali	Katwal
Holding size (ha)	5.83	3.4	2.56	5.81	2.65
Av. No. of plots per holding	3.42	2.00	4.06	2.41	2.23
Av. Area per plot (ha)	1.70	1.75	0.63	2.41	1.19
Type of soil					
Normal (%)	34.15	3.70	94.93	95.50	31.03
Margial salt affected (%)	60.97	50.00	4.35	0.20	63.80
Medium salt affected (%)	4.88	46.30	0.72	4.30	5.17
Source of irrigation					
Canal (%)	21.95	0.00	0.00	0.00	5.17
Tubewell (%)	21.95	0.00	10.14	0.00	3.45
C+T both (%)	56.10	100.00	89.86	100.00	91.38
Distance from the source (km)	1.16	0.81	0.44	0.51	0.44

problem noticed in non-SSD village Lath (46.3%). It clearly indicates that the drainage technology has contributed a lot in improving the salinity problem of the area within a shortest period of 3 years since 1997.

The source of irrigation in the selected villages was tube well and canal both covering on an average 95% of the total cultivated area except for Rewara where about 22% area each was irrigated by canal and tubewell alone and 56% by both the sources combined. The average distance of the fields from irrigation sources was 0.65 km, which was comparatively longest in the Rewara village being 1.16 km because of the largest area under canal irrigation system.

Cropping pattern

The cropping pattern of the selected farms is presented in Table 2 which reveals that the most dominant crop of the area was rice covering 72 to 85% of the total cropped land followed by sorghum fodder (10 to 14%). Pearl millet was the second important food-grain crop covered about 13% cropped area in Moi and 9% in Rewara village. It was also grown in the limited area of Bali and Katwal villages whereas nun of the farmer grew it in non-SSD village Lath mainly because of the waterlogging problem. Cotton and sugarcane were also grown by a few of the farmers On an average, 3% of the total cropped area remained fallow during kharif season due to waterlogging situation. It underlines pressing need of the drainage measures in the area so that the problematic fields could be taken up under cultivation during kharif season.

Cost on installation of drainage system

The installation cost the drainage system, estimated in the various research studied carried out by the CSSRI Karnal, was about Rs. 20000 per ha as per details

Table 2. Cropping pattern of the selected farms

(Area in %)

Particulars	Villages				
	Rewara	Lath	Moi	Bali	Katwal
Rice	72.20	85.25	75.78	81.50	72.83
Sorghum (fodder)	13.05	10.72	9.77	7.78	13.96
Pearlmillet	8.99	0.00	12.89	2.00	0.42
Cotton	2.03	0.00	0.00	0.00	0.00
Sugarcane	0.00	0.85	0.00	1.00	6.04
Fallow	3.73	3.18	1.56	7.72	0.75
Total cropped area (ha)	5.90	3.49	2.56	6.81	2.65

Table 3. Establishment and installation cost of drainage system (Standard design)

Cost Items		Cost (in %)
1.	Drainage pipes and fittings	41
2.	Earthwork and installation	37
3.	Filter material	14
4.	Construction of sumps. manholes and	8
	Total cost (Rs./ha)	20,000

Source : Tyagi, N.K. (1998) Management of Salt Affected Soils, In 50 years of natural resource management research (Ed.) ICAR, New Delhi, p. 393.

Table 4. Estimation of the annual per hectare drainage cost

	Particulars	Amount (Rs.)
1.	Fixed capital required for the system (for a period of 30 years)	20000.00
2.	Interest on fixed capital per year (@ 10%)	2000.00
3.	Interest on fixed capital per crop	1000.00
4.	Depreciation on cost of the system per year	666.66
5.	Depreciation charges per crop	333.33
	Total fixed cost per crop	1333.33

given in Table 3. It is evident from the table that the highest share of the cost was on drainage pipes and fittings being 41 per cent of the total system installation cost. Earthwork stood at second highest place accounting for 37 per cent of the total cost whereas filter material cost was 14 per cent. About 8 per cent cost was involved on construction of sumps, manholes and other charges.

The details of costs and returns for life of the project as a whole are required for estimation of average annual per hectare drainage cost. All the cost and returns are compounded or discounted in a particular point of time to work out Net Present Worth, B-C Ratio and Internal Rate of Return of a particular project. If the actual costs and returns of a project life are not available, the estimated costs and returns are used to calculate the financial parameters but it needs sufficient experience and some authentic assumptions. Beside these, the annual depreciation and interest on fixed capital of the system are also needed to be worked out. In the present study, the depreciation and interest on the fixed capital technique is adopted for the estimation of annual cost of the drainage, as only one season crop data is used for the purpose. Considering 30 years project life and 10% rate of interest on the fixed capital, the annual cost of the drainage system is calculated as per procedure shown in Table 4. The annual cost of drainage was Rs. 2666.66 per ha which estimating to Rs. 1333.33 per crop season.

Economics of crop production

The economic analysis of crops is confined only to Basmati rice and Pearl millet (Hybrid), as these were the only foodgrain crops grown in the SSD sample plots. The comparative economics of the drainage system for rice and pearlmillet crops is described below.

Rice (Basmati)

The average operational cost (i.e. cost A1) involved in rice cultivation under SSD system was Rs. 11116.17/ha. The highest share of the cost was on machine power constituting nearly 33% of the total operational cost followed by hired human labour (25%). The other important items of the cost in rice cultivation were irrigation and fertilizers who shared 17 and 15% of the total operational cost, respectively. The cost of weedicides was Rs. 301.15/ha whereas use of plant protection measures was not common in Basmati rice. The costs C1 and C2 were Rs. 14062.17 and 24062.17/ha for rice grown under sub-surface drainage, respectively.

The operational cost for rice cultivated without drainage was Rs. 11323.33/ha whereas the costs C1 and C2 estimated to Rs. 12619.06 and 22619.06/ha, respectively. The cost on machine power was Rs. 3879.86, hired human labour Rs. 2864.49 and irrigation Rs. 2002/ha. Fertilizers shared 13% of the total operational cost whereas Rs. 214.49 and Rs. 40.58 invested respectively on weedicides and plant protection chemicals for rice cultivated without drainage system.

The comparative economics of Basmati rice grown under the drainage and non-drained systems are presented in Table 5. It is evident from the table that the operational cost of Basmati rice cultivation was almost at par under both the situations. The costs C1 and C2 were 11 and 6 per cent higher for the drainage system than those of the non-drained crop were. There was remarkable difference between yield of the rice grown under drained and non-drained conditions (246 kg/ha). The yield was 17 per cent more in the drained rice plots than that of the non-drained fields. Similarly, the net income earned by the farmers under drainage condition was as high as 61% on cost A1 and 34% on cost C1 as compared to the non-drained situation. The net loss on cost C2 (including rental value of land, interest on fixed capital and imputed value of family labour) was about 16% less for rice grown under drained condition over the non-drained fields. These findings prove that the drainage technology has quite visible and favorable impact on yield and net return of the Basmati rice.

Pearlmillet (Hybrid)

The brief account of cost and return of hybrid variety of pearl millet grown with drainage system portrayed that the operational cost for pearlmillet was Rs. 4604.70/ha for SSD sampled plots. The highest share of the cost was on machine power being Rs. 2006.52/ha followed by fertilizer (Rs. 836.41). The other important items of the cost were hired human labour (Rs. 534.78/ha) and irrigation (Rs. 488.60/ha). The cost on weedicides and plant protection was almost negligible in pearl millet cultivation. The costs C1 and C2 were Rs. 8224.45 and Rs. 18224.45/ha, respectively, for pearl millet grown under sub-surface drainage system.

The operational cost of pearl millet grown without drainage was Rs. 4500.17/ha whereas the costs C1 and C2 estimated to Rs. 6797.17 and 16797.17/ha respectively. The highest share of the cost in non-SSD millet plots was on machine power constituting nearly 62% of the total operational cost followed by fertilizer and manure (Rs. 750/ha). The irrigation cost was Rs. 650/ha whereas seed shared 4.5% of the operational cost in non-drained crop. Use of weedicides, plant protection chemicals and hired labour was not common for non-SSD pearlmillet.

The comparative economics of pearlmillet, presented in Table 6, revealed that the operational cost of pearlmillet was slightly higher for drained condition than that of the non-drained whereas it was 21% higher on cost C1 and 8.5% on cost C2. It depicts that drainage system increases the cost of production significantly particularly on the basis of the costs C1 and C2. The yield of pearlmillet was 12% higher in drainage situation than that of the non-drained plots. The net income earned by the farmers in drainage system was about Rs. 300 more on cost A1 as compared to those of non-drained crop. The net loss on costs C1 and C2 was 45 and 8% more on drained condition over the non-drained. These findings indicate that drainage technology has favorable and positive impact on yield and net return of the pearlmillet crop only on the basis of the operational cost A1.

Input-output efficiency under drainage system

The statistical analysis was made for both the crops rice and pearlmillet separately but the results described here are only for the rice, as neither the coefficient of multiple determination nor regression coefficients of the explanatory variables appeared significantion the case of pearlmillet. Results of the regression analysis, presented in Table 8, revealed that coefficient of multiple determination (R^2) was significant at 5% level of probability for the rice cultivated under SSD system. The R^2 explained 44.71% variation in the

Table 5. Comparative economics of Basmati rice cultivation under Sub-Surface drainage and without drainage conditions on the sample plots

(Rs/ha)

Particulars	Without Drainage	With Drainage	% Increase over non-drainage
Production cost			
Cosat A1	11323.33	11116.17	-1.83
Cost A2	11323.33	11116.17	-1.83
Cost B1	11493.18	12616.25	9.77
Cost B2	21493.18	22616.25	5.23
Cost C1	12619.06	14062.17	11.43
Cost C2	22619.06	24062.17	6.38
Grain yield (kg)	1426.00	1672.00	17.25
Gross income	15787.83	18304.21	15.94
Net income over			
Cosat A1	4464.50	7188.04	61.00
Cost A2	4464.50	7188.04	61.00
Cost B1	4294.65	5687.96	32.44
Cost B2	-5705.35	-4312.04	24.42
Cost CI	3168.77	4242.04	33.87
Cost C2	-6831.23	-5717.96	16.30

return of the SSD rice due to variation in the use of the explanatory variables. The regression coefficient (b) was positive and highly significant at 1% level of significance for fertilizer indicating most favourable positive impact of this variable on return of the crop in special reference to the adoption of sub-surface drainage technology. It was the highest amongst all the variables considered for analysis being 10.55 which explains an addition of Rs. 10.55 for each rupee invested on fertilizer under SSD system. The b value of human labour was positive and significant at 5% level and added to Rs. 1.86 against per rupee invested on it in drainage situation. The b value of machine power was negative but non-significant whereas irrigation indicated positively non-significant coefficient which depicts that the impact of these inputs was not remarkable on return of the crop under the sub-surface drainage situation.

In the case of without drainage Basmati rice, the R^2 was significant at 5% level of probability and indicated 12.48% variation in the crop return of the explanatory variables. Non of the variable turned up significant in respect to the regression coefficient, which indicates that there was no remarkable impact of the explanatory variables on return of the rice crop cultivated under non-drained condition at the existing pattern of resource use.

Table 6. Comparative economics of Pearlmillet (HB) grown under Sub-Surface drainage and without drainage conditions on the sample plots

(Rs/ha)

Particulars	Without Drainage	With Drainage	% Increase over non-drainage
Production cost			
Cosat A1	4500.17		2.32
Cost A2	4500.17		2.32
Cost B1	4564.17		31.78
Cost B2	14564.17		9.96
Cost C1	6797.17		21.00
Cost C2	16797.17		8.50
Grain yield (kg)	1367.00		12.00
Gross income	4541.67		9.06
Net income over			
Cosat A1	41.50		739.81
Cost A2	41.50		739.81
Cost B1	-22.50		4618.22
Cost B2	-10022.50		10.36
Cost C1	-2255.50		45.03
Cost C2	-12255.50		8.29

Table 7. Results of linear multiple regression analysis made for SSD and Non-SSD Basmati rice considering return of the crop as a dependent variable and five independent production factors

Variables (X)	Intercept (a)	Regression coefficient (b)	Standard error (SE)	Coefficient of multiple determination R^2)
With Drainage (N-67)				
Human labour (Rs./ha) X_1	1205.899	1.8622*	0.9474	0.4471*
Machine power (Rs./ha) X_2		-1949	1.1603	
Fertilizers (Rs./ha) X_3		10.5533**	1.9517	
Irrigation (Rs./ha) X_4		0.0468	2.1119	
Weedicides (Rs./ha) X_5		-30.2264**	6.9680	
Without Drainage (N=35)				
Human labour (Rs./ha) X_1	7143.606	1.6786	1.2460	0.1248*
Machine power (Rs./ha) X_2		-0.6693	2.6662	
Fertilizers (Rs./ha) X_3		4.5929	3.0597	
Irrigation (Rs./ha) X_4		-2.6721	8.4580	
Weedicides (Rs./ha) X_5		-0.8902	2.3021	

* Significant at 5% level of Probability ** Significant at 1% level of Probability

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EFFECT OF MULCH, NITROGEN AND IRRIGATION LEVELS ON UPLAND RICE IN UTTRANCHAL

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ABSTRACT

To evaluate the response of June sown rice (*Oriza sativa* Linn.) to irrigation, mulching and nitrogen levels, field experiments were conducted for two year (1989-1990) in a silty clay loam soil. Paddy yield was not affected significantly due to irrigation levels and due to mulch in 1989. However mulch has increased the yield by 11.1 per cent. During both the years, rice responded significantly upto 60 kg N ha-1. The WUE was least affected by irrigation levels, but increased by 12.3% due to mulch. N application has increased the WUE by 98.5 with 30 kg N and by 169% with 60 kg N ha-1 over control.

Key words : Mulch, nitrogen, irrigation, upland rice.

June seeded rice (June-September) is a suitable alternative for double cropping over traditionally practiced spring rice (March-September) in the hills of Uttranchal state. Although kharif season has a good seasonal rainfall (Av. 763.0 mm), but some time rice crop suffers due to erratic behaviour of rainfall. Under such a situation, it becomes necessary to conserve adequate moisture in seed zone. Organic mulches are known to increase soil moisture storage (Fryrear and Koshi, 1971; Unger, 1978) and maintain a high water content in the upper few centimeters of the soil (Prihar et al., 1981).

The application of mulches masks the limitation of moisture to some extent. Crop responses to mulch application have been found to vary (Black and Siddoway, 1979). The crop response to added nutrients, particularly, N is mainly determined by available water (Benbi, 1990) and inherent fertility of the soil. The present study was therefore, conducted to evaluate the response of June sown rice under mulching and to assess the response of nitrogen under restricted and sufficient moisture condition.

MATERIALS AND METHODS

Field experiment was conducted for three years (1998-1990) with rice on a Silty clay loam soil of experimental farm Hawalbagh, Almora (29°36' N and 79°39'E, 1250 m amsl).

Rice variety, VL Dhan 163) was sown @ 100 kg seed/ha in second week of June and harvested in the first week of October every year. The nitrogen through urea was applied as per treatment. Total dose of nitrogen along with 40 kg P_2O_5/ha and 30 kg K_2O/ha were applied as basal.

The treatments consisted of three irrigation levels (rainfed, 1W:CPE 0.6 and 0.9) in main plots, two mulch (no mulch and straw mulch @ 6 t/ha) in sub plot and three nitrogen levels (0, 30 and 60 kg N/ha) in sub sub-plots. The experiment was conducted in split-split plot design replicated thrice. The soil was silty clay loam having, pH 5.8, organic carbon 0.93%, available N 285 kg/ha, available P_2O_5 16 kg/ha and available K_2O 110 kg/ha. The soil (0-15 cm depth) was analyzed by standards methods as described by Jackson (1973). Moisture retention and available soil moisture content of the experimental site have been presented in Table 1. Water use parameters were calculated as :

Profile moisture use : Soil moisture at sowing ± soil moisture at harvest

Water use : Profile moisture change ± Rainfall - Deep percolation

Accretion in profile moisture was subtracted, while depletion was added to water use. The depth of irrigation was invariably 5 cm. The weekly rainfall pattern during the course of study has been presented in Fig. 1.

RESULTS AND DISCUSSION

Grain yield

The grain yield of rice was not affected significantly due to irrigation levels (Table 2). The nonsignificant response to irrigation was mainly due to good amount of seasonal rainfall received during both the years, being 676.2 and 864.1 mm, respectively in 1989 and 1990. Only in 1989 one irrigation was given in IW : CPE 0.90. Due to mulch, mean yield increased by 11.1 per cent over no mulch. This may ascribed to maintenance of better soil moisture condition in the root zone and sustaining top soil temperature by mulch. Beneficial effect of mulch on soil moisture and temperature has also been reported by Parhar et al. 1981.

The response to N application was significant during both the years upto the maximum tested level of 60 kg/ha (Table 2). This can be attributed to good seasonal rainfall (Fig. 1), which in turn provided better soil moisture condition, which is a prerequisite for proper utilization of applied nitrogen. Pardeep et al. 1994 also reported significant response by upland rice upto 80 kg N/ha.

Water use components

Water use and water balance components under different treatments have been presented in Table 2. The profile moisture accretion was observed during both the years. This may be credited to good seasonal rainfall. It increased upto IW : CPE 0.90 in 1989, but in 1990 it remained almost comparable as in neither treatment, the evaporation reached upto the fixed criterion. Mulching has slightly more profile moisture recharge, probably by maintaining good moisture till harvest. Similarly with increasing nitrogen levels profile was recharged as crop had better soil coverage, leading to low evaporation rate.

Deep percolation of water followed almost similar trend to that of profile moisture recharge. This is evident that when profile moisture content was more deep percolation was also more.

Water use did not follow any definite

trend due to either of the factors. However, WUE, being main function of yield, varied greatly. In 1989, WUE increased with increasing amount of irrigation water was highest in IW:CPE 0.90 (30.2 kg ha^{-1} m) treatment. Application of mulch has increased the WUE by % over no mulch. The effect was more pronounced in 1989 probably owing to less seasonal rainfall (678.2 mm). The maximum response in terms of WUE was noticed due to N levels. It increased upto the highest tested level of 60 kg N ha^{-1} (mean 36.9 kg ha^{-1} mm^{-1}).

Based on this study it can be concluded that in normal rainfall year, June seeded rice don't require irrigation. However, mulch can be provided to boost the productivity. Looking to the yield, a dose of 60 kg N/ha would be optimum for upland rice.

Table 1. Available soil moisture and retention of experimental site

Depth (cm)	Volumetric moisture content 0.33 bar	15 bar	Available soil moisture (cm/m)
0–15	46.6	22.5	2.71
15–35	38.6	22.6	3.20
35–65	45.3	30.1	4.63
65–85	47.6	31.9	3.13
85–100	43.5	27.4	2.41

Table 2. Grain yield of rice as affected by irrigation, mulch and nitrogen

Treatments	Yield (kg/ha) 1989	1990	Mean
Irrigation			
Rainfed	12.6	17.5	15.1
IW:CPE 0.60	14.4	17.6	16.0
IW:CPE 0.90	16.0	18.8	17.4
C.D. at 5%	NS	NS	–
Mulching			
No mulching	13.5	17.1	15.3
Straw mulching	15.1	18.8	17.0
C.D. at 5%	NS	1.1	–
Nitrogen (kg/ha)			
0	7.5	9.6	8.6
30	14.4	17.2	15.8
60	20.9	27.2	24.1
C.D. at 5%	3.6	1.1	–

Table 3. Water use and efficiency under different treatments

Treatments	Profile moisture change (mm)		Deep percolation (mm)		Water use (mm)		WUE (kg/ha/mm)	
Irrigation	1989	1990	1989	1990	1989	1990	1989	1990
Rainfed	78.9	63.5	77.7	247.9	519.6	553.7	24.3	24.3
IW : CPE 0.60	80.0	67.0	77.1	264.2	519.0	539.8	27.9	24.7
IW : CPE 0.90	101.5	65.9	100.0	254.3	524.0	544.8	30.2	24.1
Mulching								
No mulcing	85.8	62.4	82.4	253.4	522.0	551.6	25.7	23.2
Straw mulch	87.9	68.5	87.8	257.6	525.7	537.9	29.2	25.7
Nitrogen (kg/ha)								
0	83.5	64.2	82.5	246.2	525.6	552.5	14.3	13.1
30	85.4	65.9	84.7	258.5	524.3	532.0	27.3	27.0
60	91.6	66.3	88.1	262.0	513.0	548.0	40.7	33.0

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RESPONSE OF FIVE PULSE CROPS TO DIFFERENT INOCULUMS OF ROOT-KNOT NEMATODE (*MELOIDOGYNE INCOGNITA*)

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Abstract

Five pulse crops namely; green gram (*Vigna radiata*), black gram (*Vigna mungo*), horse gram (*Dolichos biflorus*), soybean (*Glycine max*) and French bean (*Phaseolus vulgaris*) were evaluated against root-knot nematode (*Meloidogyne incognita*) infestation at three different inoculums (100, 500, 1000 juveniles) under glass house conditions. Although, in all the crops there has been recorded growth promoting effect at an inoculum of 500 (in comparison to the lowest and the highest inoculums), the variations in growth parameters (root, wt., shoot wt. and shoot length) were not always statistically significant. On the basis of root gall-index and nematode multiplication potential, soybean and horse gram were graded as highly resistant and resistant, respectively while black gram, green gram and French bean were found the nematode prone crops, in their descending order, respectively.

Key words : Pulses nematodes, response, inoculum.

Root-knot nematode (*Meloidogyne incognita*) is a major limiting factor in the production of various kharif crops, grown in the State of Himachal Pradesh, including pulse crops. Since, very limited work has been done so far pertaining to nematode problems in pulse crops (Sharma and Khan, 1993; Bhatia and Sharma, 2000), preliminary observations of various pulse crop fields, made during the year 2000 have shown wide variations in the infestation levels of the root-knot nematode. It is therefore that in the present study, local varieties of five pulse crops i.e. green gram (*Vigna radiata*), black gram (*Vigna mungo*), horse gram (Dolichos biflorus), soybean (*Glycine max*) and French bean (*Phaseolus vulgaris*) were evaluated at three inoculum levels viz., 100, 500 and 1000 2nd stage juveniles (J2) of *M. incognita*.

Materials and Methods

Three seeds of each crop were sown in earthen pots of 500 cc capacity, filled with sterilized (15 lb/inch^2 pressure) soil and sand mixture (2:1), in the month of July, 2000. Each inoculum in every crop was replicated four times. After ten days of germination, each pot was retained with only one seedling, which were inoculated with freshly hatched J2 population of the nematode, in three different inoculums. After 60 days of inoculation, plants were uprooted and the observations were recorded on plant growth parameters (root wt., shoot wt. and shoot length), root gall index and final J2 populations in pot soil. The data were analysed through factorial RBD.

RESULTS AND DISCUSSION

Results have been presented in Table 1, where different plant growth parameters have shown varied response at the different inoculums of the nematode tested.

Root weight

The three inoculums tested did not affect this parameter in any specific pattern. In green gram, lowest inoculum (100) hampered the root growth to a considerable extent (0.6 g) in comparison to the others two higher inoculums (1.9 and 1.3 g, respectively). In black gram, the inoculums of 100 and 500 showed their significant adverse effect in comparison to the highest one. In soybean and French bean, none of the inoculums could alter this parameter significantly, when compared to each other. In horse gram, the lowest and the highest inoculums reduced the root wt. (1.2 and 0.8 g, respectively) considerably, compared to the inoculum of 500.

When the three inoculums were compared for all the five crops together, it was revealed that lowest one reduced the root wt. Significantly (1.4 g) in comparison to 500, while the effect of 500 and that of 1000 were at par to each other.

Shoot weight

Although, in all the five crops this parameter was found adversely affected in the lowest and the highest inoculums in comparison to the third one (500), considerable reduction could be recorded only in horse gram (12.0 and 10.3 g, respectively as compared to 25.0 g). In soybean, highest inoculum significantly suppress the shoot growth (2.9 g), compared to others two inoculums, where the weight remained at par to each other (5 and 10g).

Comparison of three inoculums for the five crops together further depicted most adverse effect of the lowest and the highest inoculums (6.4 g) in comparison to 500 (11.6 g).

Comparison of five crops for the three inoculums together again showed that whereas, shoot wt. for green gram, black gram, soybean and French bean (5.4, 6.0, 5.8 and 7.5 g) was at par to each other, it was significantly higher (16.0 g) in horse gram.

Shoot length

Similar to the previous parameter (shoot wt.) in all the five crops highest shoot length was recorded from an inoculum of 500, in comparison to rest two inoculums. However, the variations recorded in all the three inoculums tested were statistically at par to each other in the three crops (green gram, black gram and French bean). In horse gram and soybean, highest inoculum did reduce the shoot length (40.0 and 23.3 cm) significantly, compared to others inoculums.

Comparison to the three inoculums for the five crops together again revealed that plants gained maximum length at an inoculum of 500, which was considerably higher than recorded at an inoculum of 1000.

Comparison of five crops for the three inoculums together depicted maximum shoot length in horse gram (50.6 cm) while it was least in green gram and black gram (22.3 cm).

Gall index

Whereas, gall index increased significantly at every inoculum in the three crops (green gram, black gram and French bean), it remained insignificant to each other at all the inoclulums in horse gram and soybean. The former three crops were considerablymore susceptible to the latter two.

When the five crops were compared separately for all the three inoculums in combinations, it was found that soybean is least susceptible to the nematode infestation (gall index 1.1), followed by horse gram (2.4), while black gram and green gram were found highly prone (gall index 4.4 and 4.3, respectively), followed by French bean (gall index 3.3).

Similarly, comparison of the inoculums separately for the five crops in combination showed that at every inoculum, gall index increased significantly (2.5, 3.1 and 3.5 at 100, 500 and 1000, respectively).

J2 population

Similar to gall index parameter in green gram, black gram and French bean, J2 population increased significantly in all the three inoculums tested. However, in horse gram, population remained at par to each other, while in soybean J2 population was only recorded at the highest inoculum and that too at a very low ebb.

Five crops separately with all the inoculums together, showed that there was significant variation in the J2 population, recorded from the five crops. Maximum population (114.9; transformed value) was harboured by black gram followed by green gram (92.7), French bean (55.5), horse gram (24.8), while it remained negligible (6.5) in soybean.

From the overall results it is revealed that except for horse gram and soybean although, with the increase in inoculum, there was proportionate increase in root gall index as well as J2 population, plant growth parameters were not found adversely affected accordingly. Rather at higher inoculum of 500 J2, there has been found increasing trend in the plant growth. Similar results have also been reported by Bhatia (1999) when in French bean she recorded growth-promoting effect of M. incognita up to an inoculum of 1000/500 cc pot. However, at the highest inoculum of present study, reduction in these parameters have been recorded, but these reductions were not always statistically significant from the others two inoculums.

Further, intercrop variations recorded for root wt., shoot wt. and shoot length was not to be the impact of the nematode susceptibility/resistance character (born by the plants), but it was due to the growth character of different crop plants.

It can also be said from the aforecited results that different inoculums did not affect root weight, as it increased or decreased in different pulse crops, irrespective of inoculum. However, there was a specific trend in the shoot weight and shoot length, which was found improved at 500 J2 population (in comparison to others two inoculums) in all the crops, indicating thereby that up to

Table 1. Multiplication potential and extent of damage due to M. incognita on five pulse crops at different inoculums.

Crop	Root wt. (g) at inoculums				Shoot wt. (g) at inoculums.				Shoot length (cm) at inoculums				Root gall index (1-5 scale)* at inoculums				J2 population (per pot) at inoculums			
	100	500	1000	Mean	100	500	1000	Mean	100	500	1000	Mean	100	500	1000	Mean	100	500	1000	Mean
Greengram	0.6	1.9	13	1.3c	4.3	8.0	4.3	5.4b	19.1	25.0	22.6	22.3c	3.8	4.2	5.0	4.3a	5240 (72.1)	9350 (95.8)	12360 (110.4)	92.7b
Blackgram	1.6	1.4	3.5	2.2a	4.8	7.0	6.5	6.0b	21.9	23.5	22.3	22.3c	3.8	4.5	5.0	4.4a	7280 (80.1)	14300 (118.9)	22300 (145.5)	114.9a 114.9a
Horsegram	1.2	2.6	0.8	1.5bc	12.0	25.0	10.3	16.0a	52.3	60.0	40.0	50.6a	2.3	2.3	2.5	2.4c	350 (18.6)	400 (19.9)	730 (27.0)	21.8d
Soybean	1.6	1.4	0.9	1.2c	5.0	10.0	2.9	5.8b	33.0	42.7	23.3	33.0b	1.0	1.0	1.2	1.1d	0 (1.0)	0 (1.0)	450 (17.6)	6.5e
Frenchbean	1.9	1.7	2.0	1.9ab	6.0	8.5	7.9	7.5b	26.7	28.8	30.4	28.6bc	2.0	3.5	4.5	3.3b	1175 (32.1)	4200 (48.1)	5000 (722)	55.5c
Mean	1.4b	1.8	1.6a	–	6.4b	11.6a	6.4b	–	30.6ab	36.0a	27.6b	–	2.5c	3.1b	3.5a	–	48.8b	64.7a	69.4a	–
C.D.(0.05)	T=0.47 C=0.37 T×C=0.84				T=3.31 C=2.56 T×C=5.72				T=7.56 C=5.86 T×C=13.13				T=0.35 C=0.27 T×C=0.60				T=12.81 C=9.91 T×C=22.20			

Figures in the parantheses denote transformed (n+1) values

* No. of galls	Scale
nil	1
1-10	2
11-30	3
31-100	4
>100	5

certain population level, J2 population does have growth promoting effect on the plant (probably due to the release of IAA; a growth regulator). This growth promoting effect by certain population level of the nematode and an adverse effect thereafter may be explained in the light that obviously the nematode infestation does promote the release of IAA (indol acetic acid) which is a growth promoter, but the growth of the plant is promoted till the root system remain unaffected in supplying the normal nutrient and water supply. When the nematode infestation start damaging the roots to the extent that root become unable to provide required nutrient and water supply to the eplant, growth gets adversely affected.

Hence, it can be concluded that whereas, soybean and horst gram are highly resistant and resistant crops respectively to the M. incognita infestation, black gram, green gram and French bean are the nematode prone pulse crops in their descending order respectively.

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EFFECT OF PRODUCTION FACTORS ON THE PRODUCTIVITY OF SPRING SOWN RICE UNDER RAINFED LOW HILL-VALLEY SITUATIONS OF UTTRANCHAL

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Abstract

A Field experiment was conducted at R.S. Majhera of G.B. Pant University of Agriculture & Technology, Pantnagar during 1996-98 to study the effect of production factors on the productivity of spring rice. The soil was sandy loam and alightly acidic in reaction having high organic carbon, available phosphorous and available potassium. Results revealed that integration of mulching (FYM @ 7.5 t ha-1), weed control (Pendimethalin @ 1.5 kg ha-1) and insect control (Chloropyriphos @ 4.0 lit. ha-1) practices together gave significantly higher values of growth parameters yield attributes and yield. This practice also caused significant reduciton in weed density and dry weight and shoot borer infestation.

Key words : Spring rice, rainfed, production factor, hill region.

Rice grown during spring season in low-hill valley situation of Uttranchal faces a prolonged spell of drought at early growth period resulting in low yield. Favourable response to mulching in different crops during drought conditions has been reported by many workers (Lal *et al.*, 1992; Tripathi and Bhan, 1995). Higher weed infestation, causing severe reduction in the grain yield is another major constraint of low productivity of rice in hill situation. Moody (1982) estimated 40-85% loss in yield due to severe weed competition in upland rice. Integration of suitable plant protection measure along with moisture conservation and weed control practices may further increase the productivity. Moreover, constraints of field, unawareness to latest technology as well as poor economy do not allow hill farmers to follow the modern techniques of farming. Keeping all above points in view the present study was undertaken.

Materials and Methods

A field experiment was conducted during spring season of 1996-98 at Research Station Majhera (29°28'N, 79°32'E at an elevation of MSL) of G.B. Pant University of Agriculture and Technology, Pantnagar. The soil of experimental site was sandy loam having organic carbon 1.4%, available phosphorus 29.6 kg P ha^{-1} and available potassium 336 kg K ha^{-1} with pH 6.2. Twelve treatments (Table 1) were set out in randomized block design with three replications. Rice (var. VL 206) was sown in rows, 20 cm apart, by using 100 kg seeds ha^{-1} in first week of March during all the years. The crop was uniformly fertilized with 60 kg N and 40 kg P_2O_5 ha^{-1}. The crop received 477, 655 and 750 mm rainfall during 1996, 1997 and 1998, respectively.

Results and Discussion

Effect on plant growth

The values of all the growth attributes were higher when rice crop was grown with combination of FYM mulching @ 7.5 t/ha^{-1}, weed control and insect control practices (Table 1). This was closely followed by FYM mulching @ 7.5 t ha^{-1} + weed control for plant hill sand number of tillers and weed control + pine needle mulch @ 5 t ha^{-1} for plant height. Mulching with FYM @ 7.5 t ha^{-1} came out to be the single most important factor for maintaining the highest number of plants m^{-2}. Application of pendimethalin, either alone or in combination with chloropyriphos, reduced the number of tillers significantly over farmer's practice which might be due to inhibitory effect of chemicals. Combination of mulching particularly FYM with the chemicals might have reduced the ill effect of chemicals on tiller production. Mulching with pine needle @ 5 t ha^{-1} recorded significantly short or plants in combination to even with farmers practice. This might be due to production of certain chemicals during the process of decomposition which might have antagonistic effect and reduced the height of plant significantly.

Effect on weeds

Weed density and dry matter decreased significantly with the application of pendimethalin @ 1.5 kg ha^{-1} either alone or in combination with other production factors. The lowest weed density and dry weight was recorded with farmers practice. This treatment was at par with full package of practices. The lowest weed population in farmer's practice was because of frequent (3 times) interculture operations with 'Kulta' (local hand tool) which removed the weeds more effectively than that of chemical application. Pre-emergence application of pendimethalin @ 1.5 kg ha^{-1} controlled weeds during initial stage of the crop but had a little effect on the weeds emerging out late in the season (after the on set of monsoon). Positive response to herbicide application on weed reduction was also reported by Tuteja *et al.* (1995) and Angiras and Rana (1998).

Effect on yield attributes and yield

Production factors caused significant difference on yield attributes of rice (Table 1). Adoption of mulching (FYM @ 7.5 t ha^{-1}) weed and insect control practices simultaneously gave significantly higher values of yield attributes viz., panicle length, panicle weight, grains panicle^{-1} and 1000-grain weight than other treatments. This treatment also recorded the lowest number of dead hearts m^{-1} row and unfilled grains panicle^{-1}. Application of pendimethalin @ 1.5 kg ha-1 recorded significantly lower panicle density when compared to even control.

Pooled data revealed that combination of FYM mulching @ 7.5 t ha^{-1}, weed and insect control practice being at par with FYM mulching + weed control recorded significantly higher yields over farmers practice and other individual or combination

Table 1. Effect of different treatments on growth and yield attributes of spring rice (Pooled 1996-98)

Treatment	Plant hills at harvest (m^{-1})	No. of tillers (m^{-1})	Plant height at maturity (cm)	Panicle density (panicle m^{-1})	Length panicle (cm)	Weight of panicle (g)	No. of grains $panicle^{-1}$	1000 grain weight (g)
Control	418	181.6	105.0	163.5	13.5	2.6	83.2	12.9
Farmers practice (3 HW)	44.4	195.47	114.8	178.0	20.0	4.6	134.5	20.0
Weed control (Pendimethalin @ 1.5 kg ha^{-1})	41.7	180.2	113.7	139.9	19.9	3.8	115.4	18.2
Mulching (Pine needle @ 5 t ha^{-1})	47.6	194.4	109.9	153.0	17.1	3.6	123.3	16.0
Mulching (FYM @ 7.5 t ha^{-1})	56.0	198.6	110.2	181.1	20.0	3.7	116.2	18.7
Weed control + Insect control (Chloropyriphos@4.0 kg ha^{-1})	43.1	183.0	113.2	174.8	19.4	4.2	122.3	19.0
Weed control + Mulching (Pine needle @ 5 t ha^{-1})	49.8	196.0	116.3	174.9	18.9	4.7	135.2	20.2
Weed control + Mulching (FYM @ 7.5 t ha^{-1})	56.3	211.0	115.8	174.4	21.8	4.6	141.0	21.7
Mulching (Pine needle) + Insect control	48.6	197.2	111.0	178.9	18.9	4.2	109.7	18.6
Mulching (FYM) + Insect control	52.2	204.6	112.9	182.6	21.5	4.7	120.5	18.8
Weed control + Mulching (Pine needle) + Insect control	51.2	205.8	113.5	182.9	20.5	4.6	134.3	20.0
Weed control + Mulching (FYM) + Insect control	65.3	213.6	117.2	181.7	22.3	5.0	168.2	22.7
CD at 5%	3.0	6.4	1.9	9.2	1.8	0.3	9.7	0.90

Table 2. Effect of different treatments on dead hurt, unfilled grains, weed density, weed dry matter, grain and straw yield of spring rice (Pooled 1996-1998)

Treatment	No. of dead hurts m-1 row length	No. of unfilled grains spike^{-1}	Weed density (m^{-2})	Weed dry matter (m^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Control	2.0	10.8	151.7	208.9	1058	1276
Farmers practice (3 HW)	1.0	8.6	29.3	29.0	2243	2591
Weed control (Pendimethalin @ 1.5 kg ha^{-1})	0.9	9.6	87.3	97.2	1863	2334
Mulching (Pine needle @ 5 t ha^{-1})	1.9	10.1	132.8	142.8	1744	1918
Mulching (FYM @ 7.5 t ha^{-1})	1.7	9.9	142.2	207.1	1980	2276
Weed control + Insect control (Chloropyriphos@4.0 kg ha^{-1})	0.2	6.74	83.7	82.8	1988	2387
Weed control + Mulching (Pine needle @ 5 t ha^{-1})	0.5	8.7	75.0	93.9	2368	2653
Weed control + Mulching (FYM @ 7.5 t ha^{-1})	0.4	6.5	77.9	97.2	2631	3141
Mulching (Pine needle) + Insect control	0.2	6.7	113.6	124.9	2029	2537
Mulching (FYM) + Insect control	0.2	6.5	138.9	1429	2129	2335
Weed control + Mulching (Pine needle) + Insect control	0.5	6.5	66.4	97.6	2400	2641
Weed control + Mulching (FYM) + Insect control	0.1	5.6	35.0	38.3	2753	3387
CD at 5%	0.31	0.86	9.46	26.70	353	435

of the factors. The percentage increase with the adoption of all the factors combination was to the tune of 22.7 and 160.2 over farmers' practice and control. Mulching or application of pendimethalin alone recorded lower yield than farmer's practice. This might be due to frequent inter culture operation adopted by farmer's. Continuous disturbance of soil not only controlled the weeds effectively but also provided dust mulch which was helpful in moderation of temperature and moisture conservation during mid drought period. Superiority of combination of FYM mulching + weed control + insect control over others might be due to better conservation of moisture and effective weed and insect control (Table 2) which led to better utilization of nutrients that reflected on yield attributes and yield. The results are in conformity with those of Srivastava and Srivastava, 1995.

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EFFECT OF SEWAGE-SLUDGE AND HEAVY METALS AND THEIR COMBINATIONS ON YIELD AND CONTENT OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

Screen house experiment was conducted in rabi 2000-2001 to evaluate the effect of different treatments on the yield, and their availability to *Brassica juncea* grown on a loamy sand soil. The stimulatory effect of low levels of Zn and Ni was observed on mustard stovers and seed yield. The relative toxicity of metals to mustard plants was in the order Cd>Ni>Zn. Application of Zn in combination with Ni or Cd significantly decreased its content in mustard stovers and seed in both the soils. The Ni content of stovers and seeds also decreased significantly when the same level of Ni was applied in combination as compared to individual metal application.

Key words : *Brassica juncea*, stover and seed yield, Zn, Ni, and Cd.

The rapid increase in the concentration of different heavy metals in soils due to urbanization, industrialization and use of sewage water and industrial effluents (Tiller, 1989) in recent years is a serious challenge to agricultural scientists and environmentalists. Large amount of heavy metals such as Ni, Cd, Cr, Pb etc. enter into the soil through atmospheric deposition, wastewater irrigation and solid waste dumping. Thus natural background level exceed with respect to these elements and hence, pollute the soils. Sewage-sludge is a residue, consisting of mixtures of organic and inorganic solids derived from municipal wastewater treatments. When applied as an amendment, sewage-sludge introduces, in addition to organic matter, plant nutrients and potentially harmful trace metal elements into the soil.

The continuous application of sludges may lead to the accumulation of heavy metals in soils to such an extent that may prove toxic to plants and hazardous to animals and human beings. Because of the potential hazards they may pose via food chain transfer, the chemistry and photo availability trace metals in municipal sewage-sludge and sludge amended soils have been the subject of numerous investigations. Among the trace metal elements frequently found in Sewage-sludge; Zn and Cd are usually the most readily taken up and translocated by plants grown on sludge treated soils (Logan and Chaney, 1983). Although, information on the toxic effect of Zn, Ni and Cd on some crops is available, it is lacking with regard to mustard crop. Hence, the present study was undertaken to know the toxic effect of Zn, Ni and Cd on yield and tissue content in Indian mustard (cv. RH-30) grown on soils untreated (@0%) and treated (@3%) with sludge.

MATERIALS AND METHODS

A pot experiment was conducted during rabi season of 2000-2001. A bulk soil sample (0 to 15 cm) of loamy sand soil was collected from village Ludas of district Hissar, Haryana, India. The soil was alkaline (pH-8.5), normal in salt content (EC-0.44 ds m^{-1}), low in organic carbon (0.46%), loamy sand in texture, low in available N (108.64 kg ha^{-1}), medium in available P_2O_5 (25.65 kg ha^{-1}) and high in K_2O (483.84 kg ha^{-1}) content in soil. The initial DTPA extractable Zn, Ni and Cd content were 0.68, 0.82 and 0.24 mg. The sewage-sludge was collected from sewer water treatment plant, industrial Estate, Okhla (New Delhi). The sewage-sludge was air dried, ground and sieved through 2 mm sieve. The Sewage-sludge was slightly acidic to neutral (pH-6.50), high in salt content (EC-2.70 ds m^{-1}), very high in organic carbon (12.80%), rich in total nutrients (N-1.22%, P-1.17% and K-1.06%), higher DTPA extractable metal (Zn-15.73, Ni-20.59 and Cd-1.50 mg kg^{-1}). Total metal contents of sewage-sludge were, Zn-320.00, Ni-56.30 and Cd-3.30 mg kg^{-1}.

Various levels of individual metal and their combinations were imposed as treatments-Zn (0, 10, 20, 40, 80 mg kg^{-1} soil), Ni (0, 10, 20, 40, 80 mg kg^{-1} soil), Cd (0, 10, 20, 40, 80 mg kg^{-1} soil), Zn + Ni (0, 5+5, 10+10, 20+20, 40+40 mg kg^{-1}) and Zn + Ni + Cd (0, 3.3+3.3+3.3, 6.6 + 6.6 + 6.6, 13.3 + 13.3 + 13.3, 26.6 + 26.6 + 26.6 mg kg^{-1} soil) in a differently sewage-sludge (0 and 3%) untreated and treated loamy sand soil. The experiment was carried out by using the polyethylene lined earthen pots of 25 cm internal diameter. Seventy five pots were filled with 4.85 kg soil and 150 g air dried sewage-sludge (3% sludge level). Basal doses of nitrogen, phosphorus, copper, manganese, iron were applied @ 30, 20, 2.5, 5 and 10 mg kg^{-1} soil, respectively, through their solution forms. Ten healthy seeds of mustard (cv RH-30) were sown in each pot. After emergence of seedlings, the numbers of plants were thinned to four per pot and were allowed to grow up to maturity. The pots were irrigated with deionized water as and when required. The crop was harvested at two different dates. Crop grown on sludge untreated soil was harvested at 11 days earlier than the plants of sludge teated soil. This may be due to more vegetative growth of mustard in sludge treated soil as compared to sludge untreated soil. The plants shed their leaves before maturity. The leaves were collected separately pot wise. The harvested plants and leaves were washed with 0.1 N HCl then with distilled water. The plant samples were washed and air-dried by keeping them in paper bags and then in an oven at 63-67°C to a constant weight. Thereafter, the seeds were separated and the dry weight of stovers and seeds were recorded. The stovers were ground in a stainless steel grinder, mixed and stored in polyethylene bags for chemical analysis. All the dried plant parts were digested in 4:1 di acid mixture (HNO_3 and $HClO_4$) for analysing Zn, Ni and Cd contents. For statistical interpretation factorial completely randomized design (CRD) was followed by taking three replications.

RESULTS AND DISCUSSION

Yield of mustard

Applications of sewage-sludge cause a significant increase in the yield of mustard stovers irrespective of levels of heavy metals Table 1. The stovers yield increased from 13.50 to 21.58 g pot^{-1} with an increase in the level of sewage-sludge. The beneficial effect of sewage-sludge was also observed in metal contaminated soil. The yield of stover due to application of Zn at 80 mg kg^{-1} soil increased from 11.95 to 22.00 g pot^{-1} with an increasing sludge level from 0 to 3%, respectively, while that of the same increase was 11.75 and 20.60 g pot^{-1} respectively with Ni application. The magnitude of decrease in yield due to Zn and Ni, however, was much less as compared to Cd, which suggested that Cd affects more towards the yield decrement. The stovers yield decreased from 13.50 to 0.99 g pot^{-1} with increasing Cd levels from 0 to 80 mg kg^{-1}, respectively in sludge untreated soil. The addition of sludge almost counteracted the adverse effect of Cd on plant growth as the stover yield decreased was from 21.58 to 10.11 g pot^{-1} with increasing Cd level from 0 to 80 mg kg^{-1} soil in sludge treated soil, respectively while that of the same yield decreased to a great extent (0.99 g pot^{-1}) at 80 mg kg^{-1} Cd in soils without sludge application. Application of Zn in combination with Ni and Cd was also found useful in counteracting the toxic effect of these metals on Brasica juncea being most effective when there were in lowest levels both in sludge treated and untreated soils. But the effect was more clear in case of Cd. The stover yields were 2.55 and 18.36 g pot^{-1} in soils enriched with 40 mg Cd kg^{-1} soil, but when same amount of zn was applied along with 40 mg kg^{-1} Ni the yield increased from 12.35 to 22.78 g pot-1 in sewage-sludge untreated and treated soil, respectively. Zinc was found more effective and beneficial in counteracting the phyto-toxic effect of Cd on mustard stover as the stover yield increased from 2.55 to 6.83 g pot^{-1} in sludge untreated soil when Cd was applied in combination with Zn (Zn_{40}+Cd_{40}). Similar trend was also observed in case of Zn+Ni+Cd levels.

The mustard seed yield was also influenced by the application of different metals and their combinations. The stimulatory effects of Zn and Ni were observed in seed yield at their application level of 20 mg kg^{-1} soil. Among the metals, cd was found more toxic to mustard as the relative decrease n seed yield was recorded maximum (2.78 g pot^{-1}) in Cd contaminated soil. Application of sewage-sludge was found beneficial as it caused a significant increase in seed yield at all the levels of metals. It was further observed that the seed formation could not take place at Cd level 80 mg kg^{-1} in sewage-sludge untreated soil. However, the seed yield increased from nil to 2.78 g pot^{-1} when the same soil was amended with sewage-sludge at 3% level suggesting a beneficial effect of sewage-sludge application in case of either individual metal application or their combinations. The increased yields of stover and seed were observed with an increase in sludge level from 0 to 33% (Table 1). Such increased

Table 1. Effect of sewage-sludge and metals on Stovers and seed yield of Indian mustard (cv. RH-30)

Metals(mg kg^{-1})	Stover Yield (g pot^{-1})			Seed Yield (g pot^{-1})		
	Without sludge	With sludge	Mean	Without sludge	With sludge	Mean
Control	13.50	21.58	17.54	5.69	13.28	9.48
Zn_{10}	14.88	25.73	20.30	6.91	16.51	11.71
Zn_{20}	14.65	25.28	19.96	6.50	15.93	11.21
Zn_{40}	12.60	22.86	17.73	6.12	14.06	10.09
Zn_{80}	11.95	22.00	16.97	5.78	13.71	9.75
Ni_{10}	14.11	25.16	19.63	6.53	16.31	11.42
Ni_{20}	12.92	24.17	18.55	6.25	15.84	11.05
Ni_{40}	11.92	22.77	17.35	5.63	14.63	10.13
Ni_{80}	11.75	20.60	16.18	5.30	12.27	8.79
Cd_{10}	12.94	20.67	16.80	5.72	13.02	9.37
Cd_{20}	11.38	18.85	15.12	2.87	12.30	7.59
Cd_{40}	2.55	18.36	10.46	0.30	10.57	5.44
Cd_{80}	0.99	10.11	5.55	*	2.78	1.39
Zn_5+Ni_5	15.14	26.66	20.90	8.40	13.79	11.09
$Zn_{10}+Ni_{10}$	14.57	25.50	20.04	7.58	16.47	12.02
$Zn_{20}+Ni_{20}$	14.27	24.47	19.37	6.62	16.11	11.37
$Zn_{40}+Ni_{40}$	12.35	22.78	17.56	6.22	14.61	10.41
Zn_5+Cd_5	14.94	23.25	19.09	6.62	13.65	10.14
$Zn_{10}+Cd_{10}$	13.52	22.51	18.02	6.28	13.11	9.70
$Zn_{20}+Cd_{20}$	12.25	20.52	16.39	3.77	12.62	8.20
$Zn_{40}+Cd_{40}$	6.83	17.01	11.92	0.95	9.97	5.46
$Zn_{3.3}+Ni_{3.3}Cd_{3.3}$	14.15	22.89	18.52	7.59	12.27	9.93
$Zn_{6.6}+Ni_{6.6}Cd_{6.6}$	13.38	22.21	17.79	7.01	10.25	8.63
$Zn_{13.3}+Ni_{13.3}Cd_{13.3}$	12.37	17.55	14.96	6.27	9.66	7.97
$Zn_{26.6}+Ni_{26.6}Cd_{26.6}$	12.01	13.11	12.56	4.39	8.28	6.33
Mean	12.08	21.46		5.41	12.88	

CD (5%) :

Sludge	:	0.18	Sludge	:	0.19
Metals	:	0.62	Metals	:	0.66
Sludge × Metals	:	0.88	Sludge × Metals	:	094

* There was no siliqua development.

yield might be due to the additional plant nutrients supplied through the sludge and the subsequent improvement in soil physical properties. Similar results were also observed by Varies (1983). The response of mustard to the application of n was also recorded and this may be ascribed to the initial marginally low amount of DTPA extractable Zn (0.68 mg kg^{-1}) in the experimental field soil. Hence the application of Zn might have resulted in balanced nutrition and hence higher stover and seed yield. Similarly, stimulatory effect of Ni was also observed at 20 mg kg^{-1} in the soil. Increase in dry mater yield with the addition of Zn + Ni was also observed by Sharma and Jain (1991); Matwaly and Rabie (1989).

The relative decrease in yield of both plant parameters was more in case of Cd. The stover and seed yield of mustard decreased with an increasing levels of Cd in soils treated and untreated with sludge. The relative decrease in the yield parameter in sludge untreated and treated soil was in the order Cd>Ni>Zn.

Panwar et al. (1999) reported that with an increasing levels of Cd there was a significant decrease in the dry matter yield of cowpea and mungbean which also supports the results of present investigation. The decrease in yield at higher levels of Cd was mainly due to toxicity and also pretly due to ionic imbalances (Wichman et al, 1983). Excessive application of Zn has been reported to decrease the leaf area index and dry matter yield of wheat (Singh et al, 1991). Mahler et al. (1982) also reported that yield of crops decreased with an increase in Ni and Cd levels.

Zn, Ni and Cd content in stover and seed

Zn content

The Zn content in both mustard stover and seed increased significantly with an increasing level of Zn in soil in presence and absence of sludge. Application of sewage sludge at 3% caused a significant increase in Zn content in stover. Application of Cd in combination with Zn to soils treated and untreated with sludge resulted in decrease in the Zn content in stover as compared to mustard grown on soils applied with Zn alone and Zn + Ni in combination. The Zn content of stover varied with treatments particularly in combination of multimetals (Zn+Ni+Cd).

The Zn content of mustard seeds was significantly lower than that of stover. However, with an increasing levels of Zn, its content recorded in seeds increases. The Zn content of mustard seed increased significantly with its level either alone or in combination with Ni or Cd or Ni+Cd. The Zn content of seed ranged from 4.18 and 6.30 to 10.88 and 12.79 mg kg^{-1} with an increasing Zn levels from 0 to 80 mg kg^{-1} soil both in sewage treated and untreated soil, respectively. The zn content of mustard seeds was significantly lower when it was applied in combination with Ni or Cd as compared to the treatment where Zn alone was applied which was also followed a similar trend to that of stover. Among the metals, Cd was found effective in decreasing the Zn content of the seed when applied in combination with Zn, which might be due to the antagonistic relationship between Cd and Zn.

Zinc content in tissues increased with its increasing levels of application to the soil. The accumulation of metals by plants grown on contaminated soil will not only be affected by a particular metal but will also be influenced by its interaction with other metallic ions present in the soil. The results also indicated that the content of Zn was affected by combinations of other metals. The increasing levels of sludge and metals have resulted in an increase metal content in mustard stover and seed. Increasing application of sludge has also been reported to increase Zn content in plants by Sanders et al. (1987) and Dev et al (1987).

Ni content

Nickel content of mustard stover and seed also increased significantly with its increasing levels of application to the soil. The Ni content of stover increased from 2.22 to 35.05 mg kg^{-1} with an increase in its level from 0 to 80 mg kg^{-1}, respectively in sewage sludge untreated soil. However, the application of sewage-sludge caused an increase in the Ni concentration in stover at its all levels. The Ni content increased from 2.50 to 36.21 mg kg^{-1} with its increasing levels from 0 to 80 mg kg^{-1} in sludge-amended soil. The Ni content of stovers was significantly lower in the stovers of the plants grown on Zn + Ni and Zn + Ni + Cd contaminated soils than Ni alone. The Ni content was drastically declined when it was applied in combination with Zn + Cd as compared to Ni alone. The Ni content of the seed also increased significantly with its increasing levels both in sludge untreated and treated soils. The Ni content of seed increased from 1.92 to 15.31 and 2.14 to 16.03 with an increase in its level from 0 to 80 mg kg^{-1} soil in seeds of the plant grown on sewage-sludge untreated and treated soils, respectively. Ni content of seed also showed and increasing trend when Ni was applied along with Zn (Zn_{40}+Ni_{40}) as compared to Ni_{40} alone.

The Ni content of mustard stovers and seed increased significantly with its level either applied alone or in combination with Zn and/or Zn + Cd. The increased content of Ni with its increasing rate of application to the soil was observed by Patel et al. (1976).

The increase in Ni concentration in crops also reported by Patel et al. (1976) with increasing multimetal levels in soils which also supports the results of present investigation. The increased concentration of Ni in plants grown on sludge amended soil may be due to increased rate of Ni extractability in presence of sludge and also due to formation of soluble complexes of Ni with organic matter present in the sludge.

Cd content

Cadmium content of stoves and seeds increased significantly with its increasing levels of its application to the soil. The Cd concentration increased from 0.94 to 25.63 mg kg^{-1} soil in stover with an increasing Cd level from 0 to 40 mg kg^{-1} in sewage-sludge untreated soil. The Cd content in stover also increased with its increasing levels in sludge treated soil. The data in table further show that Cd content of both stover and seed decreased in the treatment when Cd was added in combinations either with Zn or Zn + Ni in both sewage-sludge untreated and treated soil as compared to Cd alone. The Cd content in stover at its 40 mg kg^{-1} level (CD_{40}) in the soil was 25.63 mg kg^{-1} as compared to 17.44 mg kg^{-1} when the same amount of Cd was added with 40 mg Zn kg^{-1} soil (Zn_{40} + Cd_{40}).

The Cd content of mustard stover and seed increased with its increasing levels either alone or in combination with Zn and Ni. Significant quantity of Cd translocated from stover to grain. This shows that Cd is highly mobile in both soil and plant systems as evidenced from the diffusion coefficient of Cd. Cadmium is highly toxic among the other two metals (Zn and Ni) studied. Hence, the results suggested a higher accumulation of Cd in the edible parts of mustard causing clinical disturbances resulting from increased dietary intake in animals and human beings. It is also found that the soil contaminated with Cd alone caused higher accumulation in plant parts than soil/waste contaminated with Zn and Ni along with Cd. The increased content of Cd in stover and seed due to sludge application may be ascribed to its higher extractability or availability to plants in sludge treated soil. The increased content of Cd in plant parts with its increasing levels of application was also observed by Juwarkar and Shende (1986). The decreased content of Cd in stover and seed when applied in combination with Zn or Ni was also observed by Smilde et al. (1992).

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EFFECT OF PRIMARY PROCESSING ON MICROBIAL LOAD OF WATER CHESTNUT AND SPONGE GOURD

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ABSTRACT

The influence of Pre-harvest (Salt, Sugar and KMS dip) and storage atmosphere ambient, cool chamber and cool store) on storage life, quality and microbial load of primary processed water chestnut (*Trapa bisinosa* Roxburg) and Sponge gourd (*Luffa cylindrica* Roem) were studied. The result showed that samples at ambient condition registered minimum shelf life (1-day). However, the same can be stored for 3-days in cool chamber and 5-days in cool store conditions. It is also evident from the result that washing of sponge gourd in tap water reduced microbial load as compared to unwashed samples. Use of potassium meta bisulphite was found effective in reducing both bacteria and fungi. Storage at lower temperature results slow growth of microbes. Similarly, sponge gourd samples at lower temperature resulted in lower microbial growth as compared to samples stored at higher temperature.

Key words : Primary processing, microbial load, water chestnut, sponge gourd.

Primary processing or Minimal processing (invisible processing) is a combination of different methods and preservation factors (Huxsoll and Bolin, 1989) involving optimum processing of product with retention of fresh fruit or vegetable like quality of the products and to make ti ready to eat (Ahvenainen, 1996). Minimally processed or lightly processed operations have also been defined as those procedures such as washing, sorting, trimming, peeling, slicing, chopping etc. that do not affect the fresh like quality of the fruit or vegetable. Such procedures provide convenient ready to use fresh products that can be prepared and consumed in less time. But these lightly processed vegetables can be contaminated with many spoilage organisms including yeasts, moulds and bacteria because of their high moisture content and large number of cut surfaces. These two conditions are good enough that can provide ideal conditions for the growth of microorganisms and production of endogenous enzymes which enhance respiration and activities of microorganisms (Carline *et al.*, 1993). Furthermore, some of the bacteria that may be present including Clostridium botulinum and Listeria monocytogene are pathogenic to consumers (O beirne, 1999). These products thus, require careful handling and low storage temperature. Markets for minimally processed products such as shredded cabbage, require packages that ensure products safety while preserving freshness and extending shelf-life (Omary *et al*; 1993). Packaging of minimally processed products in permeable polymeric film, semi-rigid containers or both can reduce oxygen concentration and increase carbon dioxide concentration in the package atmosphere, thereby slowing degradative quality changes and increase product shelf life. Modified atmosphere packaging with elevated CO_2 and reduced O_2 has been found useful for storage of minimally processed fruits and vegetables since it reduces respiratory activity, prevent browning and microbial decay (Ko *et al*; 1996). Bolin and Huxoll (1989) also reported that modified and controlled atmosphere and anaerobic packaging with gas absorbent are useful for minimally processed fruits and vegetables. The present investigation was under taken to study the effect of primary processing on microbial load of Water chestnut and Sponge gourd.

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MATERIALS AND METHODS

Water chestnut was procured from local market and brought to the laboratory, PHT, IARI, New Delhi. After removing diseased and deformed pieces, kernels were washed and peeled. Only sound kernels were selected for the experiment. The kernels were dipped either in 2% salt, 2% sugar or 200 ppm KMS for 30 minutes. The untreated fruits kept as control. The treated and untreated kernels were spread on perforated aluminum trays to drain out excess water. These kernels were again kept in a cabinet drier maintained at 40°C for 20-30 minutes to remove the surface moisture. About 150 gm kernels were filled in each polythylene bag (200 gauge) and closed with rubber band. These bags were stored at room temperature (RT, 22-24°C), cool chamber (CC, 5-17°C) and cool store (5-6°C) to record physical and microbiologial parameters. In case of Sponge gourd, the vegetables were washed and peeled with stainless stell peeler. This peeled Sponge gourd washed again in potable water and cut into pieces (2-3 cm) of uniform size. These pieces were kept in cabinet drier maintained at 40°C for 10 minutes to remove the surface moisture. About 100 gm pieces were filled in each polyethylene bag (200 guage) and sealed with rubber band. The bags are stored at three different temperatures viz. 5°C, 10°C and 15°C and microbiological parameters were recorded at different interval of time.

Microbiological Analysis

The samples were subjected to microbiological analysis initially and after 1-day interval up to 5 days in case of both water chestnut and Sponge gourd. The samples were analyzed for the population of bacteria, fungi and presence of E. coli. in standard plate count Agar (Harrigan and M.C. Cance, 1966), Martin Rose Bengal Agar (Martin, 1950) and BCP broth media (Seeley and Van Denmark, 1970) respectively. Appropriate dilutions were plated on respective media and incubated at 30°C for 24-48 hours. The results were expressed in terms of cfu/g of sample. For E Coli. 10^{-1} and 10^{-2} dilutions were inoculated in BCP lactose broth tubes and incubated at 37°C for 48 hours and observations were taken for acid and gas production. If tubes recorded positive for acid and gas, then it was considered positive for the presence of coliforms/soil borne bacteria, Aerobacter.

RESULTS AND DISCUSSION

The present investigation showed that the bacterial population increased in all treatments and storage conditions during storage of water chestnut kernels (Table 1). It was interesting to note that during the first 3 days, the growth was slow and then, it increased and maximum growth was observed on 5th days in both cool store and cool chamber. Whereas, the samples at ambient condition registered maximum bacterial population and hence minimum shelf life (1-day). After that rapid discoloration occurs and samples become unfit for consumption. This might be due to high temperature prevalent during summer month and oxidation of soluble phenolic compounds (Ke and Saltveit, 1989C). The processed chestnut can be stored for 3 days in cool chamber and 5 days in cool store. However, in both chamber and cool store microbial population was found at safe level even on 5th days and 9th days respectively. The present findings are in conformity with that of Bracket, (1987).

The reason behind this might be low temperature during storage in cool store (cs) and cool chamber (cc) coupled with polyethylene packaging which might have created modified atmosphere inside the package. This finding was in conformity with that of Bolin *et al.*, (1997) who observed that low temperature storage extends the shelf life of minimally processed products. Beyong and Kliefer (1999) also observed increase in shelf life of about 7-10 days when minimally processed processed chinese cabbage was packed in low oxygen and high carbon dioxide atmosphere, and stored at 5°C. At ambient condition maximum bacterial count was recorded in control followed by sugar treatment and minimum in KMS (200 ppm). The same finding was also recorded in cool store even after 5-days storage but in cool chamber, maximum count was found in sugar treated nuts followed by control and minimum in salt. Sulfur Dioxide has been used to control microorganisms in fruits and vegetables and is also well known to be effective against mold, yeast and bacteria (Dziezak, 1986). No fungal growth was noticed in the samples treated with KMS and stored at ambient temperature for 1-day but found positive with salt and sugar treatments. The same observation was recorded in both cool store and in cool chamber after 5-days storage, respectively (Table 2). Samples didn't show presence of E.coli. in any of the treatment during storage.

It is clear from Table 3(a) that minimally processed Sponge gourd supported the growth of both bacteria and fungi. Bredit and Fleming (1997) observed that minimally processed products posses large cut surfaces and nutrients allowing the growth of spoilage and pathogenic organisms. High moisture and nutrient contents in addition to a neutral pH makes vegetable capable of supporting the growth of many types of microorganism. In general, vegetables are about equally contaminated with bacteria and fungi (Brackett and Split stoesser, 1992). Washing of sponge gourd in tap water brought about more than 25% reduction in bacterial population. Saji *et al.*, (2002) also reported that washing of cauliflower florets in tape water reduced about 25% reduction in bacterial population. Splittstoesser et al., (1964) also reported that water sprays on pea might remove more than 90% of microorganism. It was also observed that peeling caused reduction in microbial population as peeled Sponge gourd registered initially lowest bacterial count. Fungal population was recorded only in peel portion which was not washed) and the bacterial population was highest in unwashed peel than washed peel. This finding was in conformity with that of Ru yin Chen *et al.*, (1997) who reported that washing reduced the total microbial content of cut chive by 0.50–0.70-log cfu/g. The samples stored at low temperature (5°C) registered minimum bacterial and fungal population and longer shelf-life (4-days) as compared to others (Table 3(b) & 3(c)). The longer shelf-life at low temperature (5°C or below) is well established fact by many workers. All the samples stored were tested for the presence of E.coli., including peel washed and unwashed. It was found that E. coli was absent in peeled sponge guard, while unwahsed peel samples were found contaminated with a soil borne bacteria, Aerobacter. This indicate that unpeeled and unwashed samples of Sponge gourd were not fit for consumption. It can be concluded from the result that water chestnut could be processed into packed food item and can be stored for at least 3-5 days but Sponge gourd is more sensitive for microbial growth because of its high moisture content.

Table 1. Changes in bacterial population (x 10^4 cfu/g) of Water chestnut kernel during different stages of storage

Treatments		After 1 day	After 3 days	After 5 days
Salt-2% (RT)*	T_1	19.0	–	–
Salt-2% (CC)	T_2	11.59	128.5	190.0
Salt-2% (CS)	T_3	9.67	149.8	132.9
Sugar 2% (RT)*	T_4	20.15	–	–
Sugar 2% (CC)	T_5	11.75	231.0	259.3
Sugar 2% (CS)	T_6	10.47	181.2	246.0
KMS-200 ppm (RT)*	T_7	16.5	–	–
KMS-200 ppm (CS)	T_8	9.82	193.0	201.3
KMS-200 ppm (CS)	T_9	7.01	134.1	150.0
Control (RT)*	T_{10}	20.3	–	–
Control (CC)	T_{11}	11.24	221.4	311.2
Control (CS)	T_{12}	10.97	154.5	216.0
CD at 5%				
Treatments (T)		2.01	12.99	17.48
Storage Intervals (I)		2.33	18.38	24.72
(T×I)		5.33	25.98	34.96

* Samples stored at room temperature deteriorated after 2-days

Table 2. Changes in fungal population (x 10^1 cfu/g) of Water chestnut kernel during different stages of storage

Treatments		After 1 day	After 3 days	After 5 days
Salt-2% (RT)*	T_1	2.33	–	–
Salt-2% (CC)	T_2	0.00	3.86	20.00
Salt-2% (CS)	T_3	0.00	0.00	0.00
Sugar 2% (RT)*	T_4	3.12	–	–
Sugar 2% (CC)	T_5	0.00	3.00	20.33
Sugar 2% (CS)	T_6	0.00	0.00	13.33
KMS-200 ppm (RT)*	T_7	0.00	–	–
KMS-200 ppm (CS)	T_8	0.00	2.00	10.63
KMS-200 ppm (CS)	T_9	0.00	0.00	0.00
Control (RT)*	T_{10}	3.88	–	–
Control (CC)	T_{11}	3.00	2.00	30.00
Control (CS)	T_{12}	0.00	0.00	19.53
CD at 5%				
Treatments (T)		0.43	0.50	2.67
Storage Intervals (I)		0.50	0.70	3.77
(T×I)		0.87	0.99	5.33

* Samples stored at room temperature showed deteriorated of food item within 3-days

Table 3(a). Initial microbial population (cfu/g) of sponge gourd

	Bacteria	Fungi
Peel-unwashed	3.0×10^6	4×10^2
Peel-washed	12.0×10^6	0.8×10^2
Peeled sponge gourd	0.06×10^6	0.4×10^2
SEm±	1.34	0.03
CD at 5%	3.81	0.09

Table 3(b). Bacterial population × 10^4 cfu/g of peeled sponge gourd

Treatments	0 day	2 day	4 days	6 days
T_1 (5°C)	6.1	2.00	2.33	37.2
T_2 (10°C)	6.47	2.13	11.0	40.0
T_3 (15°C)	6.17	2.21	21.20	45.0
CD at 5%				
Treatments (T)		2.01		
Storage Intervals		2.33		
T × I		4.03		

Table 3(c). Fungal population × 10^2 cfu/g of peeled sponge gourd

Treatments	0 day	2 day	4 days	6 days*
T_1 (5°C)	0.589	1.18×10^2	13.33×10^2	–
T_2 (10°C)	0.47	2.81×10^2	22.44×10^2	–
T_3 (15°C)	0.56	5.00×10^2	71.00×10^2	–
CD at 5%				
Treatments (T)		2.01		
Storage Intervals		2.33		
T × I		4.03		

* Uncountable fungal population

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DIRECT, RESIDUAL EFFECT OF APPLIED ZINC ALONGWITH FYM ON RICE IN SOILS OF KONKAN REGION OF MAHARASHTRA

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ABSTRACT

Pot culture experiments were conducted on four Zn deficient soils of Konkan region of Maharashtra to see direct and residual effect of applied Zn in rice-rice cropping system. In direct effect, application of 25 kg $ZnSO_4$ ha^{-1} or 10 Kg Zn chelate ha^{-1} was at par and significantly increased paddy yield over NPK. However, these two treatments individually combined with 10 t FYM ha^{-1} produced significantly higher yield over other treatments and were found at par with each other. The zinc uptake by straw, grain and content in soil was increased when zinc was applied. It was significantly higher when zinc was combined with FYM. Application of zinc forms with and without FYM resulted in significant increase in grain and straw yield of subsequent rice crop. The zinc uptake and available zn in the soil increased significantly where zn was applied for first crop. The treatments comprising application of 25 kg $ZnSO_4$ ha^{-1} and 10 kg Chelated-Zn were at par.

Key words : Zn defienent, direct and residual effect, cropping system, zinc sulphate and chelated zinc, FYM.

Practice of intensive cropping with HYVS, continuous use of high analysis fertilizers, increase in command area, use of low organic manures, mining and plant agriculturally progressive states of our country. Rice is the major cereal crop grown in deficiency has been noticed in Konkan soils and continuous submergence aggravate the problem. Devarajan *et al.* (1987) reported that soil application of zinc sulphate over the recommended dose of N, P and K is needed for zinc deficient soils to maximize rice yield. The escalating price of inorganic micronutrients besides their rapid solubility and unavailability to plants due to soil reactions led to recommendation of chelates as an alternate source to enhance the availability of native and applied micronutrients to plant. Application of zinc has been found to exert an appreciable influence on crop and soil for a relatively large period of time influencing direct, residual, cumulative effect of aplied zinc on yield and uptake by rice. Pot culture experiments were therefore designed to study the direct, residual effect of applied zinc alongwith FYM on rice in soils of Konkan region.

MATERIALS AND METHODS

Pot culture experiments were conducted on four Zn deficient soils from Konkan region viz., lateritic (Typic Ustropepts) heavy clay (Vertic Ustropepts), medium black (Vertic Ustropepts) collected from Dapoli, Repoli, Karjat and Palghar locations. The physico-chemical properties of the soils used for experiment are given in table 1. The details of treatments used in the investigation were, control (NPK), NPK + 25 kg $ZnSO_4$ ha^{-1}; NPK + 10 kg Zn chelate ha^{-1}, NPK + 10 t FYM ha^{-1}, NPK + 10 t FYM ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} and NPK + 10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1} and four soil types. All together, there were twenty four treatment combinations under factorial completely randomized design with three replications. Jaya rice variety was used as test crop for two seasons.

First crop (summer) was transplanted during February, 2000 and subsequent crop was transplanted during June 2002 (kharif) without incorporating FYM and zinc forms. A basal dose of N, P_2O_5 and K_2O was applied at recommended levels for both the crops. Soil sampling at different crop growth stages was also carried out to determine available zn. After harvest of each crop, soil samples were collected and analyzed for available zn by DTPA method of Lindsay and Norvell (1978). Plant samples were digested in diacid mixture (concentrated HNO_3 and $HClO_4$ in the ratio of 2 : 1 respectively), Richards (1954). Zinc was estimated in triacid extract of a plant samples with Varian-AA-1475, atomic absorption spectrophotometer. Standard methods were followed for other soil analysis.

Table 1. Physical-chemical properties of the soils

Properties	Lateritic soil (Dapoli)	Heavy clay soil (Repoli)	Medium black soil (Karjat)	Medium black soil (Palghar)
A) Physical properties				
i) Bulk density (Mg m^{-3})	1.28	1.54	1.46	1.48
ii) Textural class	Clay	Clay	Clay.	Clay
B) Chemical properties				
i) pH	5.25	6.85	7.14	7.32
ii) EC dS m^{-1}	0.08	0.14	0.14	0.97
iii) Organic carbon (%)	2.11	0.78	1.29	0.74
iv) Free $CaCO_3$ (%)	0.75	3.25	3.25	4.25
v) CEC [c mol (p$^+$) kg^{-1}]	36.62	40.96	45.30	38.30
vi) Av. N. (kg ha^{-1})	212.25	295.16	265.12	281.18
vii) Av. P. (kg ha^{-1})	7.95	18.25	18.71	11.07
viii) Av. K. (kg ha^{-1})	235.20	190.40	145.60	282.91
ix) Av. Zn (mg kg^{-1})	0.45	0.48	0.42	0.43

RESULTS AND DISCUSSION

Direct effect

Grain and straw yield

There were significant differences in the grain yield of rice among four different soils under study. Soils from Dapoli was lateritic in nature, dominant in kaolinite clay minerals and had low fertility, hence the yields were low (Table 2). Irrespective of soils, application of $znSO_4$ @ 25 kg ha^{-1} of Zn chelate @ 10 kg ha^{-1} produced grain yield 51.60 g pot^{-1} and 51.02 g pot^{-1}, respectively were significantly higher over control (NPK). The results are in agreement with those of Bansal *et al.* (1992); Trivedi *et al.* (1998) and Rajendra Prasad *et al.* (2000). It was also observed that treatment comprising 25 kg $ZnSO_4$ ha^{-1} (5.68 kg Zn ha^{-1}) was at par with 10 kg Zn chelate ha^{-1} (1.2 kg Zn ha^{-1}). High solubility and stability of zn chelates beside its increased movement of ions to the plants might have helped to increase the grain yield. Similar results regarding efficiency of zn chelates have been reported by Sahu *et al.* (1994) and Revathi *et al.* (1996). Results revealed that application of 25 kg $ZnSO_4$ ha^{-1} with 10 t ha^{-1} FYM (64.69 g pot^{-1}) produced significantly higher yield over treatment control and zinc forms. The beneficial effect of FYM application on rice yield was expected as it contributed directly to the nutrient pool of the soil and increased their availability through chelation or by mobilizing some of the native soil zn for

Table 2. Rice yield, Zn content and uptake by grain and straw as affected by soils, sources of Zn and FYM (Direct effect)

Treatment	Yield (g pot^{-1})		Zn content (mg kg^{-1})		Zn uptake (mg pot^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Soil (Dapoli)	48.24	53.29	41.07	37.68	2.03	2.07
Soil (Repoli)	55.86	64.63	28.05	24.77	1.62	1.66
Soil (Karjat)	60.99	72.47	29.25	26.92	1.83	2.00
Soil (Palghar)	51.62	60.88	30.36	27.95	1.61	1.74
S.Em. ±	0.72	1.00	1.10	0.95	0.06	0.06
C.D. at 5%	2.49	2.84	3.13	2.60	0.18	0.17
Control (No zinc)	41.38	47.49	23.44	20.64	0.96	0.96
25 kg ZnSO4 ha^{-1}	51.60	59.90	32.51	30.21	1.66	1.77
10 kg Zn chelate ha^{-1}	51.02	58.35	30.54	28.35	1.54	1.62
10 t FYM ha^{-1}	52.88	60.80	26.87	24.53	1.39	1.46
10 t FYM ha^{-1} + 25 kg ZnSO4 ha^{-1}	64.69	75.96	40.89	37.18	2.63	2.80
10 t FYM ha^{-1} + kg Zn chelate ha^{-1}	63.50	74.39	38.84	35.08	2.45	2.57
S.Em±	0.88	1.23	1.35	1.12	0.08	0.08
C.D. at 5%	1.49	3.48	3.83	3.19	0.22	0.21
Soil × treatment						
S.Em±	1.75	2.44	2.69	2.24	0.16	0.15
C.D. at 5%	NS	NS	NS	NS	NS	NS

crop. Similar results were reported by Devarajan and Krishnaswamy (1996) and Chitdeshwari and Krishnasamy (1997).

The results in respect of straw yield were observed to be similar to the grain yield (Table 2). The application of forms of zinc increased the rice straw yield ver control. These results are in agreement with those reported by Sakal *et al.* (1991) and Trivedi *et al.* (1998). The treatments 10 t FYM ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} (75.96 g pot^{-1}) and 10 t FYM ha^{-1} + 10 kg Zn chelate (74.39 g pot-1) were significantly superior over all other treatments indicating the importance of FYM in dry matter production. Similar results were reported by Chitdeshwari and Krishnaswamy (1997).

Zn content and uptake by rice

While comparing the effect of various treatments of zinc content and uptake by rice grain and straw, it was observed that Dapoli soil showed maximum zinc content as well as its uptake (Table 2). This may be due to high zinc supply parameter of the Dapoli soil and acidic reaction compared to other soils under study. It was also seen that application of 25 kg $znSO_4$ ha^{-1} or 10 kg zn chelate ha^{-1} significantly increased zinc content and uptake by rice grain as well as straw. These findings are in agreement with those of Trivedi *et al.* (1998) and Rajendra Prasad *et al.* (2000). The treatment comprising 10 t FYM ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} to 10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1} indicated significantly higher zinc uptake both in grain and straw of rice in all other treatments. Similar results were recorded by Singh *et al.* (1998).

Available zinc content in soil.

The data presented in table 3 indicated that Dapoli soil was significantly superior over soils from Repoli, Karjat and Palghar in respect to the available zn content at all the stages of crop growth. This may be because of high supply parameter value of lateritic soil dominant in kaolinite minerals and low pH. Ganjir *et al.* (1973) stated that higher values of available zn could be attributed to the lower pH. Rajendra Prasad (1992) reported that adsorption maximum was in the trend of smectite > illite > kaolinite. He also concluded that desorption was low in montmorillonite clay minerals. Application of 25 kg $znSO_4$ ha^{-1} and 10 kg zn chelate ha^{-1} significantly increased DTPA-zn in soil at all stages of crop growth over control (table 4). The higher solubility, diffusion and mobility of the applied inorganic zinc fertilizer might be the reason for increased zn status. Chitdeshwari and Krishnasamy (1997) reported that application of 5 mg zn kg^{-1} increase DTPA zn in soil at maximum tillering, panicle initiation and at harvest stage. Trivedi *et al.* (1998) stated that on an average, the DTPA-Zn after harvest increased from original value. Application of 10 t FYM ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} and 10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1} increased significantly the DTPA-Zn content in soil over other remaining treatments. The beneficial effect of FYM was expected as it contributed directly to the nutrient pool of the soil and increased their availability through chelation or mobilizing some of the active soil Zn. Devarajan and Krishnasamy (1996) reported beneficial effect of zinc enriched organic manures on available zinc content in soil after harvest of crop.

Table 3. Rice yield, Zn content and uptake by grain and straw as affected by soils, sources of zinc and FYM (Residual effect)

Treatment	Yield (g pot^{-1})		Zn content (mg kg^{-1})		Zn uptake (mg pot^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
Soil (Dapoli)	35.45	39.53	33.58	30.25	1.23	1.25
Soil (Repoli)	45.64	55.86	23.06	22.00	1.09	1.28
Soil (Karjat)	46.42	54.46	25.04	22.62	1.19	1.26
Soil (Palghar)	43.80	53.03	25.19	23.68	1.14	1.30
S.Em. ±	0.58	0.67	0.84	0.88	0.04	0.05
C.D. at 5%	1.64	1.92	2.37	2.50	NS	NS
Control (No zinc)	31.14	36.79	18.59	16.72	0.57	0.62
25 kg ZnSO4 ha^{-1}	40.68	47.86	27.88	25.18	1.12	1.18
10 kg Zn chelate ha^{-1}	39.72	47.03	26.11	23.84	1.02	1.10
10 t FYM ha^{-1}	41.66	48.77	22.58	20.12	0.93	0.97
10 t FYM ha^{-1} + 25 kg ZnSO4 ha^{-1}	52.48	62.51	33.57	31.79	1.74	1.96
10 t FYM ha^{-1} + kg Zn chelate ha^{-1}	51.28	61.34	31.58	30.16	1.60	1.82
S.Em±	0.71	0.83	1.03	1.08	0.05	0.06
C.D. at 5%	2.01	2.35	2.91	3.06	0.14	0.17
Soil × treatment						
S.Em±	1.41	1.65	2.05	2.15	0.09	0.12
C.D. at 5%	NS	NS	NS	NS	NS	NS

Residual effect

Grain and straw yield

Data presented in table 3 indicated that Repoli, Karjat and Palghar soils produced significantly higher grain yield over Dapoli. The yields were affected due to difference in the fertility of the soil. The treatment of 25 kg ZnSO$_4$ ha^{-1} and 10 kg Zn chelate ha^{-1} produced significantly higher yield over control. These results indicated the significance of Zn residual effect on succeeding rice grain yield. Takkar *et al.* (1975) and Khurana *et al.* (1996) reported that the carryover effects of Zn significantly enhanced the yield over control. The results further revealed that the treatments comprising the application of 10 t FYM ha^{-1} + 25 kg ZnSO$_4$ and 10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1} were at par and significantly superior over other treatments, indicating significance of FYM in maintaining residual effect. Similar results were reported by Sakal *et al.* (1985) and Chitdeshwari and Krishnasamy (1997).

The residual effect of Zn on straw yield indicated that the treatments 25 kg ZnSO$_4$ ha^{-1} and 10 kg Zn chelate ha^{-1} produced significantly higher yield over control (Table 3). Devarajan and Ramanathan (1995) observed that the residual effect of applied Zn was significant on straw yield of rice in rice-rice cropping. The treatment comprising the application of 10 t FYM ha^{-1} + 25 kg ZnSO$_4$ ha^{-1} and 10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1} were at par with each other and significantly superior over other

Table 3. Available zinc content in the soil (mg kg^{-1}) as affected by soil, sources of zinc and FYM at different growth stages of rice (Direct and residual effect)

Treatment	At maximum tillering		At panicle initiation		At harvest	
	Grain	Straw	Grain	Straw	Grain	Straw
Soil (Dapoli)	0.92	0.73	1.29	0.87	1.50	1.07
Soil (Repoli)	0.79	0.69	1.09	0.85	1.30	0.99
Soil (Karjat)	0.86	0.69	1.16	0.84	1.37	1.01
Soil (Palghar)	0.88	0.70	1.19	0.83	1.38	0.99
S.Em. ±	0.04	0.03	0.04	0.03	0.05	0.04
C.D. at 5%	0.09	0.07	0.12	NS	0.13	NS
Control (No zinc)	0.32	0.26	0.36	0.27	0.38	0.30
25 kg ZnSO4 ha^{-1}	0.74	0.62	1.14	0.80	1.36	1.05
10 kg Zn chelate ha^{-1}	0.68	0.53	1.07	0.72	1.25	0.98
10 t FYM ha^{-1}	0.49	0.48	0.76	0.56	0.92	0.60
10 t FYM ha^{-1} + 25 kg ZnSO4 ha^{-1}	1.52	1.25	1.90	1.39	2.26	1.62
10 t FYM ha^{-1} + 10 kg Zn chelate ha^{-1}	1.45	1.13	1.88	1.33	2.16	1.53
S.Em±	0.04	0.06	0.05	0.04	0.06	0.05
C.D. at 5%	0.12	0.09	0.15	0.11	0.16	0.14
Soil × treatment						
S.Em±	0.08	0.06	0.11	0.07	0.11	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS

treatments. Similar results were recorded by Singh *et al.* (1998) in rice-wheat cropping system.

Zinc content and uptake by grain straw

The residual effect of various treatments on zinc content and its uptake revealed that application of 25 kg $ZnSO_4$ ha^{-1} and 10 kg Zn chelate ha^{-1} significantly increased Zn content and uptake by grain and straw over control and 10 t FYM ha^{-1} (Table 3). Combination of FYM with Zn significantly increased the content and uptake in grain and straw over treatment without FYM. Similar results were recorded by Sakal *et al.* (1985), Islam *et al.* (1997).

Available Zn content in soil during crop growth period

It could be stated from the results presented in table 4 that residual effect of 25 kg $ZnSO_4$ or 10 kg Zn chelate ha^{-1} increased the available Zn content in soil at all stages of crop growth over treatment control. These results are in agreement with the results noted by Chitdeshwari and Krishnasamy (1997), Islam *et al.* (1997). Residual effect at FYM + zinc increased growth the available Zn content in the soil over control and Zn (alone) treatments. These results are in agreement with the result obtained by Devarajan and Krishnasamy (1996).

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EFFECT OF INSECTICIDES ON THE EXTENT OF POD DAMAGE AND SEED DAMAGE BY PODFLY (*MELANAGROMYZA OBTUSA* MALLOCH) AND POD BORER (*HELICOVERPA ARMIGERA* HUBNER) IN BAHAR CULTIVAR OF PIGEONPEA

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ABSTRACT

Field experiments were conducted during kharif season of 1994-95 and 1995-96 at the Agriculture Research Farm, Banaras Hindu University, Varanasi to assess the effect of insecticides on the extent of pod damage and seed damage by podfly (Melanagromyza obtusa Malloch) and pod borer (Helicoverpa armigera Hubner) in Bahar cultivar of pigeonpea. The relative effect of seven insecticides, each applied in two different schedules were found significantly superior over the control in reducing the pod and seed damage by both the pests. The minimum pod damage 7.25% and seed damage 5.95% by podfly was observed in monocrotophos treated plots followed by endosulfan, cypermethrin, fenvalerate, deltamethrin, carbaryl, malathion while pod damage and seed damage both were maximum in the control plot (38.58% and 19.56%, respectively). The insecticide endosulfan was the best insecticide which recorded minimum pod (4.08%) and seed damage (2.32%) by pod borer while these were maximum in the control plot which exhibited 19.00% and 10.57% pod and seed damage, respectively. The insecticides sprayed two times first at flowering and pod formation stage and second 25 days after the first spray was found significantly superior over single application applied at flowering and pod formation stage in reducing the pod damage as well as seed damage. The insecticide monocrotophos recorded maximum yield in Bahar cultivar 24.85 q/ha treated plot followed by endosulfan, cypermethrin, fenvalerate, deltamethrin, carbaryl, malathion while these were minimum yield in the control plot 13.16 q/h.

Key words : Podfly, pod borer, Bahar and insecticide.

The pigeonpea pod associated pests such as podfly (*Melanagromyza obtusa* Malloch) and pod borer (*Helicoverpa armigera* Hubner) are recognised as the major pests of pigeonpea in Varanasi, U.P. which infest the crop causing damage to the extent of 55.94% and 32.47% in pod and seed, respectively (Kumar and Nath, 2002). To meet the growing demand of pulses to feed the ever-increasing human population the productivity of the pigeonpea crop is to be increased by preventing the damage caused by these two major pests.

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Insecticide is one of the most effective methods available to the farmers for control of pests of pigeonpea. Keeping these facts in view the experiments were conducted to help in the selection of suitable insecticide on the basis of their relative efficacy in reducing the extent of pod damage and seed damage by the podfly and pod borer infesting Bahar cultivar of pigeonpea at Varanasi, Uttar Pradesh.

MATERIALS AND METHODS

The experiments were conducted at the Agriculture Research Farm, Banaras Hindu University, Varanasi to evaluate the effect of synthetic insecticides on the extent of pod damage and seed damage by podfly (M. obtusa) and pod borer (H. armigera) infesting pigeonpea variety Bahar. The pigeonpea crop was raised during kharif season fo 1994 and 1995 at the research farm having treatment plot size of 4.2 × 2.7 m under normal agronomical practices. The spacing between two rows and two plants were 60 × 30 cm. The insecticides such as monocrotophos 36 SL (0.004%), endosulfan 35 EC (0.07%) and malathion 5 D (5.00%) were applied in two different schedules. In the first schedule all the insecticides were applied only once at flowering and pod formation stage while in the second schedule the insecticides were applied two times first alongwith the application of first schedule and second application was given 25 days later to the first application. The liquid formulation of insecticides was applied with the help of hand compression sprayer while hand rotary duster was used for the application of dust formulation. The pods of each of the five randomly selected plants from three middle rows of each plot were picked up from the trials. The pod damage caused by pod borer was analysed by counting the total number of pods and the number of pods showing characteristics borer holes. The pod borer (H. armigera) infested pods were identified on the basis of circular hole comparatively of bigger size made on the pod while the small exit hole on the pod prepared by the larva to facilitate the adult emergence is the characteristic damage symptom of the podfly (Melangromyza obtusa). The commonly followed procedure was adopted for assessing the pod damage. The number of pods having one or more exit holes from a known number of pod samples was observed and counted. The damage caused to the seeds by podfly was assessed by counting the number of healthy and damaged seeds from teh 50 pod samples selected randomly from each plot. The grain yield data were converted in q/ha and analysed.

The pigeonpea pod and seed damage was assessed by using the following formula:

$$1.\ \text{Per cent pod damage} = \frac{\text{No. of damaged pod}}{\text{No. of total pods examined}} \times 100$$

$$2.\ \text{Per cent seed damage} = \frac{\text{No. of infested seeds out of 50 pod samples examined}}{\text{Total No. of seeds out of 50 pod samples collected}} \times 100$$

RESULTS AND DISCUSSION

The insecticides applied in two different schedules significantly reduced the pod damage and the seed damage by podfly and pod borer in comparison to control during different years in pigeonpea cultivar Bahar (Table 1, 2, 3 & 4). The average damage by podfly was observed minimum in monocrotophos (7.25% pod damage and 5.95% seed damage), treated plots followed by endosulfan (7.83% pod damage and 6.48% seed damage), cypermethrin (8.16% pod damage and 6.83% seed damage), fenvalerate (9.16% pod damage and 7.33% seed damage), deltamethrin (10.33% pod damage and 7.99% seed damage), carbaryl (10.66% pod damage and 8.58% seed damage), malathion (11.33% pod damage and seed 8.91% seed damage) while the maximum recorded in control plot (38.58% pod damage and 19.56% seed damage) (Tables 1 & 2). The findings of the present investigation are in conformity to those recorded by Chhabra and Kooner (1979) with monocrotophos that recorded higher efficacy against podfly incidence. The second schedule of insecticides application was found significantly superior over first schedule in reducing the pod damage as well as seed damage. These results supported those recorded by Balasubramanian *et al.* (1976) with two sprays.

The pod borer showed differential response to insecticidal treatments. Endosulfan was the best insecticide which recorded significantly reduced per cent pod damage (4.08%) and seed damage (2.32%). The efficacy of remaining insecticides against this pest was in order of monocrotophos (pod damage 4.58%, seed damage 2.78%) followed by cypermethrin (pod damage 4.92%, seed damage 3.07%), fenvalerate (pod damage 5.42%, seed damage 3.32%), deltamethrin (pod damage 5.75%, seed damage 4.21%), carbaryl (pod damage 6.08%, seed damage 4.44%) and malathion (pod damage 6.92%, seed damage 4.6%) while the control plots exhibited pod damage and seed damage to the extent of 19.00% and 10.57%, respectively (Tables 3 & 4). The results of this study find support from Balasubramanian *et al.* (1976). While Talati *et al.* (1983) observed reduced damage of pod borer in pigeonpea crop treated with endosulfan. The effectiveness of monocrotophos against pod borer and podfly is also reported by Babu and Rajasekaran (1984). The effectiveness of synthetic pyrethroids against pod borer is reported by various workers. Siddappaji *et al.* (1985) reported the efficacy of pyrethroids, on the basis of their screening test. The insecticies deltamethrin, cypermethrin and fenvalerate reduced the damage over the control caused by this pest to the tune of 69.2%, 50.4% and 46.3% and 51.7%, 30.7% and 60.7% increase in yield. The earlier reports which are in conformity with the present findings in case of carbaryl and fenvalerate are of Mhase *et al.* (1987) and in case of pyrethroids and endosulfan are of Singh *et al.* (1988). The insecticide monocrophos treated plots yielded 24.85 q/ha followed by endosulfan (22.92 q/ha), cypermethrin (21.37 q/ha), fenvalerate (20.90 q/ha), deltamethrin (21.01 q/ha), carbaryl (19.48 q/ha), malathion (18.86 q/ha) and control (13.16 q/ha) (Table 5). Sinha Srivastava (1989) and Diddappaji *et al.* (1985) tested monocrotophos and three pyrethroid, cypermethrin, fenvalerate

Table 1. Effect of insecticides on the extent of pod damage (%) by podfly (*Melanagromyza obtusa* Malloch) in Bahar cultivar of pigeonpea during 1994-95 and 1995-96 at Varanasi

Years/Insecticides	1994-95			1995-96			Pooled		
	Schedules		Average	Schedules		Average	Schedules		Average
	S_1	S_2		S_1	S_2		S_1	S_2	
Monocrotophos	8.67	6.33	7.50	8.00	6.00	7.00	8.33	6.16	7.25
(0.04%)	(17.12)	(14.53)	(15.82)	(16.41)	(14.15)	(15.28)	(16.76)	(14.34)	(15.55)
Fenvalerate	10.33	8.00	9.17	10.00	8.33	9.16	10.16	8.16	9.16
(0.02%)	(18.72)	(16.41)	(17.56)	(18.42)	(16.77)	(17.59)	(18.57)	(16.59)	(17.58)
Cypermethrin	9.67	7.00	8.33	9.33	6.67	8.00	9.50	6.83	8.16
(0.006%)	(18.05)	(15.32)	(16.68)	(17.79)	(14.93)	(16.36)	(17.92)	(15.12)	(16.52)
Carbaryl	11.67	10.00	10.83	11.33	9.67	10.50	11.50	9.83	10.66
(5.00%)	(19.96)	(18.42)	(19.19)	(19.65)	(18.08)	(18.86)	(19.80)	(18.25)	(19.02)
Deltamethrin	11.33	9.33	10.33	11.33	9.33	10.33	11.33	9.33	10.33
(0.004%)	(19.65)	(17.75)	(18.70)	(19.65)	(17.77)	(18.71)	(19.65)	(17.76)	(18.70)
Endosulfan	9.33	6.67	8.00	9.00	6.33	7.66	9.16	6.50	7.83
(0.07%)	(17.79)	(14.93)	(16.36)	(17.44)	(14.51)	(15.97)	(17.61)	(14.72)	(16.16)
(Malathion	12.33	11.00	11.66	11.67	10.33	11.00	12.00	10.66	11.33
(5.00%)	(20.54)	(19.36)	(19.95)	(19.65)	(18.72)	(19.18)	(20.09)	(19.04)	(19.56)
	39.67	40.33	40.00	36.67	37.67	37.17	38.17	39.00	38.58
Control	(38.65)	(39.09)	(38.87)	(37.27)	(37.86)	(37.56)	(37.96)	(38.47)	(38.21)
	14.12	12.33	13.23	13.41	11.79	12.62	13.76	12.05	12.92
Average	(21.31)	(19.47)	(20.39)	(20.78)	(19.09)	(19.93)	(21.04)	(19.28)	(20.16)

Figures in parentheses are angular transformed values.

		1994-95	1995-96	Pooled
Difference between insecticides	C.D. (P=0.05) =	1.35	1.40	1.03
Difference between schedules	C.D. (P=0.05) =	1.68	0.70	0.52
Interaction between insecticides × schedules	C.D. (P=0.05) =	N.S.	N.S.	N.S.

Table 2. Effect of insecticides on the extent of seed damage (%) by podfly (*Melanagromyza obtusa* Malloch) in Bahar cultivar of pigeonpea during 1994-95 and 1995-96 at Varanasi

Years/Insecticides	1994-95			1995-96			Pooled		
	Schedules		Average	Schedules		Average	Schedules		Average
	S_1	S_2		S_1	S_2		S_1	S_2	
Monocrotophos	6.02	5.31	5.67	6.51	5.92	6.22	6.27	5.62	5.95
(0.04%)	(14.13)	(13.26)	(13.70)	(14.73)	(14.01)	(14.37)	(14.43)	(13.64)	(14.04)
Fenvalerate	7.65	6.43	7.04	8.28	6.95	7.62	7.97	6.69	7.33
(0.02%)	(15.99)	(14.65)	(15.32)	(16.67)	(15.23)	(15.95)	(16.33)	(14.94)	(15.64)
Cypermethrin	7.02	5.96	6.49	7.82	6.49	7.16	7.42	6.23	6.83
(0.006%)	(15.30)	(14.10)	(14.70)	(16.22)	(15.07)	(15.65)	(15.76)	(14.59)	(15.18)
Carbaryl	8.86	7.70	8.28	9.38	8.36	8.87	9.12	8.03	8.58
(5.00%)	(17.28)	(16.05)	(16.67)	(17.85)	(16.78)	(17.32)	(17.57)	(16.42)	(16.99)
Deltamethrin	8.25	7.15	7.70	8.80	7.73	8.27	8.53	7.44	7.99
(0.004%)	(16.66)	(15.58)	(16.12)	(17.22)	(16.11)	(16.67)	(16.94)	(15.85)	(16.40)
Endosulfan	6.47	5.84	6.16	7.26	6.32	6.79	6.87	6.08	6.48
(0.07%)	(14.99)	(14.02)	(14.51)	(15.60)	(14.53)	(15.07)	(15.30)	(14.28)	(14.79)
(Malathion	9.18	7.98	8.58	9.78	8.70	9.24	9.48	8.34	8.91
(5.00%)	(17.59)	(16.37)	(16.98)	(18.15)	(17.12)	(17.64)	(17.87)	(16.75)	(17.31)
	19.03	18.41	18.72	21.71	20.08	20.40	19.87	19.25	19.56
Control	(25.77)	(25.38)	(25.58)	(27.4)	(26.59)	(26.82)	()26.41	(25.99)	(26.20)
	9.06	8.10	8.58	9.82	8.82	9.32	9.44	8.46	8.95
Average	(17.21)	(16.18)	(16.70)	(17.94)	(16.93)	(17.44)	(17.58)	(16.56)	(17.07)

Figures in parentheses are angular transformed values.

		1994-95	1995-96	Pooled
Difference between insecticides	C.D. (P=0.05) =	0.64	0.47	0.53
Difference between schedules	C.D. (P=0.05) =	0.32	0.24	0.27
Interaction between insecticides × schedules	C.D. (P=0.05) =	N.S.	N.S.	N.S.

Table 3. Effect of insecticides on the extent of pod damage (%) by pod borer (*Helicoverpa armigera* Hobner) in Bahar cultivar of pigeonpea during 1994-95 and 1995-96 at Varanasi

Years/Insecticides	1994-95			1995-96			Pooled		
	Schedules		Average	Schedules		Average	Schedules		Average
	S_1	S_2		S_1	S_2		S_1	S_2	
Monocrotophos	5.33	3.33	4.33	5.67	4.00	4.83	5.50	3.66	4.58
(0.04%)	(13.34)	(10.34)	(11.84)	(13.69)	(11.48)	(12.58)	(13.51)	(10.91)	(12.21)
Fenvalerate	6.33	4.00	5.16	6.67	4.67	5.67	6.50	4.33	5.42
(0.02%)	(14.51)	(11.48)	(12.99)	(14.93)	(12.46)	(13.69)	(14.72)	(11.97)	(13.34)
Cypermethrin	5.67	3.67	4.67	6.00	4.33	5.16	5.83	4.00	4.92
(0.006%)	(13.73)	(11.02)	(12.37)	(14.15)	(12.00)	(13.07)	(13.94)	(11.51)	(12.72)
Carbaryl	7.33	4.67	6.00	7.33	5.00	6.16	7.33	4.83	6.08
(5.00%)	(15.66)	(12.46)	(14.06)	(15.66)	(12.88)	(14.27)	(15.66)	(12.67)	(14.17)
Deltamethrin	6.67	4.33	5.50	7.00	5.00	6.00	6.83	4.66	5.75
(0.004%)	(14.93)	(12.00)	(13.46)	(15.32)	(12.88)	(14.10)	(15.12)	(12.44)	(13.78)
Endosulfan	4.67	3.00	3.83	5.00	3.67	4.33	4.83	3.33	4.08
(0.07%)	(12.42)	(9.98)	(11.20)	(12.88)	(10.96)	(11.92)	(12.65)	(10.47)	(11.56)
(Malathion	7.67	5.33	6.50	8.33	6.33	7.33	8.00	5.83	6.92
(5.00%)	(16.02)	(13.34)	(14.68)	(16.74)	(14.44)	(15.59)	(16.38)	(13.89)	(15.14)
	18.67	18.33	18.50	19.33	19.67	19.50	19.00	19.00	19.00
Control	(25.54)	(25.34)	(25.44)	(26.07)	(26.31)	(26.19)	(25.80)	(25.82)	(25.82)
	7.79	5.83	6.81	8.17	6.58	7.37	7.98	6.21	7.09
Average	(15.77)	(13.25)	(14.51)	(16.18)	(14.18)	(15.18)	(15.97)	(13.71)	(14.85)

Figures in parentheses are angular transformed values.

		1994-95	1995-96	Pooled
Difference between insecticides	C.D. (P=0.05) =	1.54	1.77	1.12
Difference between schedules	C.D. (P=0.05) =	0.77	0.88	0.56
Interaction between insecticides × schedules	C.D. (P=0.05) =	N.S.	N.S.	N.S.

Table 4. Effect of insecticides on the extent of seed damage (%) by pod borer (*Helicoverpa armigera* Hobner) in Bahar cultivar of pigeonpea during 1994-95 and 1995-96 at Varanasi

Years/Insecticides	1994-95			1995-96			Pooled		
	Schedules		Average	Schedules		Average	Schedules		Average
	S_1	S_2		S_1	S_2		S_1	S_2	
Fenvalerate	3.78	3.04	3.41	3.50	2.96	3.23	3.64	3.00	3.32
(0.02%)	(11.16)	(9.90)	(10.53)	(10.67)	(9.77)	(10.22)	(10.92)	(9.84)	(10.38)
Cypermethrin	3.41	2.96	3.19	3.18	2.70	2.94	3.30	2.83	3.07
(0.006%)	(10.57)	(9.80)	(10.19)	(10.18)	(9.40)	(9.79)	(10.38)	(9.60)	(9.99)
Carbaryl	5.14	4.33	4.74	4.60	3.66	4.13	4.87	4.00	4.44
(5.00%)	(13.12)	(12.09)	(12.57)	(12.29)	(10.94)	(11.62)	(12.71)	(11.48)	(12.10)
Deltamethrin	4.79	4.08	4.40	4.44	3.52	3.98	4.62	3.80	4.21
(0.004%)	(12.10)	(11.58)	(11.84)	(12.10)	(10.72)	(11.41)	(12.10)	(11.15)	(11.63)
Endosulfan	2.73	2.10	2.42	2.46	1.97	2.22	2.60	2.04	2.32
(0.07%)	(9.44)	(8.26)	(8.85)	(8.96)	(8.04)	(8.50)	(9.20)	(8.15)	(8.68)
(Malathion	5.48	4.41	4.95	4.73	3.81	4.27	5.11	4.11	4.61
(5.00%)	(13.29)	(12.06)	(12.68)	(12.51)	(11.18)	(11.85)	(12.90)	(11.62)	(12.26)
	11.53	10.85	11.19	10.19	9.70	9.95	10.86	10.28	10.57
Control	(19.82)	(12.21)	(16.02)	(18.59)	(18.11)	(18.35)	(19.21)	(15.16)	(17.19)
	5.00	4.31	4.65	4.49	3.86	4.17	4.75	4.08	4.42
Average	(12.45)	(10.65)	(11.55)	(11.86)	(10.91)	(11.38)	(12.16)	(10.78)	(11.47)

Figures in parentheses are angular transformed values.

		1994-95	1995-96	Pooled
Difference between insecticides	C.D. (P=0.05) =	0.72	0.64	0.59
Difference between schedules	C.D. (P=0.05) =	0.36	0.32	0.29
Interaction between insecticides × schedules	C.D. (P=0.05) =	N.S.	N.S.	N.S.

Table 4. Effect of insecticides on the extent of seed damage (%) by pod borer (*Helicoverpa armigera* Hobner) in Bahar cultivar of pigeonpea during 1994-95 and 1995-96 at Varanasi

Years/Insecticides	1994-95			1995-96			Pooled		
	Schedules		Average	Schedules		Average	Schedules		Average
	S_1	S_2		S_1	S_2		S_1	S_2	
Monocrotophos (0.04%)	22.90	26.05	24.48	23.56	26.88	25.22	23.23	26.47	24.85
Fenvalerate (0.02%)	18.99	21.98	20.49	19.77	22.82	21.30	19.38	22.40	20.90
Cypermethrin (0.006%)	19.50	22.53	21.02	20.07	23.37	21.72	19.79	22.95	21.37
Carbaryl (5.00%)	17.61	20.58	19.10	18.36	21.34	19.85	17.99	20.96	19.48
Deltamethrin (0.004%)	18.11	21.18	19.65	18.82	21.89	20.36	18.47	21.54	20.01
Endosulfan (0.07%)	20.66	24.05	22.36	21.74	25.21	23.48	21.20	24.36	22.92
(Malathion (5.00%)	17.14	19.92	18.53	17.80	20.55	19.18	17.47	20.24	18.86
Control	13.18	13.05	13.12	13.27	13.10	13.19	13.23	13.08	13.16
Average	18.51	21.17	19.84	19.17	21.90	20.53	18.84	21.53	20.19

Figures in parentheses are angular transformed values.

		1994-95	1995-96	Pooled
Difference between insecticides	C.D. (P=0.05) =	0.34	0.32	0.28
Difference between schedules	C.D. (P=0.05) =	0.17	0.16	0.14
Interaction between insecticides × schedules	C.D. (P=0.05) =	N.S.	N.S.	N.S.

and deltamethrin resulted in the highest yields. The effectiveness of sprays containing 0.07% endosulfan and dust containing 5% carbaryl and 5% malathion increasing significantly the yield of crop (Chaudhury and Rastogi, 1980). The plots under second schedule produced more (21.53 q/ha) than the plots treated under first schedule (18.84\ q/ha) of insecticide application.

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COMBINING ABILITY OF NEW MALE STERILE LINES IN PEARL MILLET EVALUATED UNDER RAINFED CONDITION

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ABSTRACT

Combining ability estimation was done in a line × tester analysis of crosses involving five new male sterile lines and three restorers of pearl millet (Pennisetum glaucum (L) R. Br.), evaluated under rainfed condition. Variances showed the presence of enough diversity in the material used for all the traits except days to maturity. Female parents, ICMA-93333, ICMA-96111 and RMS-3A and male parents RIB-20K-86 and RIB-3135-18 were identified as good general combiners. The crosses namely; ICMA-93333×RIB-3135-18, ICMA-95444×RIB-3135-18, RMS-3A×RIB-20K-86, ICMA-96111×RIB-20K-86 and ICMA-93333×RIB-335-74 were found desirable, having significant specific combining ability (s.c.a.) effects and higher per se performance. The identified parents would use further in breeding programme and the selected hybrids would be evaluated at different location. Among the selected hybrids ICMA-93333×RIB-3135-18 was tested at 19 locations and showed its superiority over the checks.

Key words : Line × Tester, general combining ability (g.c.a.), specific combining ability (s.c.a.), hybrid, *Pennisetum glaucum.*

Pearlmillet (*Pennisetum glaucum* (L) R. Br.) is a drought tolerant crop, which is grown in rainfed conditions of North-West India. The land races adopted for such conditions are widely grown by the farmers of this region and efforts to replace it with hybrids are continued. The adoption of hybrids will depend on their higher yield under water stress condition and resistance to downy mildew. One of the great consequence in hybrid development is the male sterile line under use must have high general combining ability (g.c.a.), so that it can combine well with an array of R-lines to produce a large number of hybrids. Hence an experiment was conducted to study the combining ability of certain newly devolved male sterile lines under rainfed condition for their use in hybrid development programme.

MATERIALS AND METHODS

Five male sterile lines namely; ICMA-93333, ICMA-96111, ICMA-95444 and ICMA-95555 (developed at ICRISAT, Patancheru) and RMS-3A (developed at ARS Durgapura, Jaipur Rajasthan ; using local land races of this region) were crossed with three genetically divers restorer lines; viz. RIB-20K-86 and RIB-3135 and RIB-335-74 in Line × Tester fashion in Summer-

1999. All hybrids along with their parents were grown under rainfed condition with recommended cultural practices in randomized block design with three replications in Kharif-1999. Each entry (parents/F_1s) was grown in two rows of 5 m length with a row spacing of 50 cm and 15 cm within a row. Observations were recorded on 5 randomly selected plants for six quantitative traits viz : days to 50% flowering, grain yield/plant (gm), days taken to maturity, plant height (cm), ear length (cm) and productive tillers (no./plant). Mean values were used for line × tester analysis (Kampthorne. 1957) to obtain combining ability estimates. One of the selected hybrids, ICMA-93333×RIB-3135-18 (RHB-127) was evaluated in All India Co-ordinated Pearlmillet project (Initial Hybrid Trial India-Zone-A), at 19 locations along with 31 hybrids and 5 checks during in Kharif-2000.

RESULTS AND DISCUSSION

Mean squares due to parents, lines and tester were significant for all the traits (Gill et al. 1969 and Burton. 1983), except for days to maturity. These results indicated diversity among the parents. Similarly significant variation among hybrids for all the traits were also noted. Mean square due to "parent vs hybrid" were significant for all the traits indicating presence of heterosis (Yadav. 1999).

A desirable line under rainfed condition is one, which flowers and matures earlier, and generally taller, coupled with higher grain yield. Hence negative general combining ability (g.c.a.) effects for days to 50% flowering and days to maturity are desirable, and positive estimates are required for rest of the traits.

General combining ability (g.c.a.) effects due to additive genetic effect and it is fixable (Symmond. 1979). None of the parents estimated desirable g.c.a. effects for all the traits simultaneously (Table 1). Male sterile lines, ICMA-93333 and ICMA-96111 had higher mean value and significant g.c.a. effects for grain yield and productive tiller. Both the lines were found be undesirable for days to 50% flowering. The line ICMA-93333 had highest g.c.a. effects for grain yield. The ICMA-96111 also had significant and desirable g.c.a effects for other traits viz; plant height and ear length. On the other hand male sterile lines RMS-3A, ICMA-95444 and ICMA-95555 had significant and desirable g.c.a. effects for days to 50% flowering but showed undesirable effects for grain yield except RMS-3A. RMS-3A also had significant and desirable g.c.a. effects for days to maturity and plant height. The restorer RIB-20K-86 had higher mean value, significant and desirable g.c.a. effects for grain yield, days to maturity and productive tillers, where RIB-3135-18 also gave similar results for 50% flowering and ear length only.

Similar to g.c.a. effects, s.c.a. effects (Table 2) also revealed that none of the cross had desirable s.c.a. effects for all the traits simultaneously. Such results have earlier reported by Rao and Reddy; 1982. Seven out of fifteen hybrids were found to be significant s.c.a. effects for grain yield. The hybrid ICMA-93333×RIB-3135-18 had the highest mean value and significant s.c.a. effects in a desirable direction for grain yield and productive tillers. The hybrid RMS-3A×RIB-20K-86 exhibited significant s.c.a.

Table 1. General combining ability effects and per se performance of parents

Parents	50% Flowering	Grain yield/plant (g)	Days to maturity	Plant height (m)	Ear length (cm)	Productive tillers (no./plant)
Lines						
ICMA-93333	2.07**	3.34**	2.82**	-0.07	-1.12**	0.08**
	(50.33)	(8.03)	(80.33)	(144.33)	(18.98)	1.70
ICMA-96111	3.29**	0.69**	0.60	4.15**	1.32**	0.29**
	(47.67)	(10.8)	(77.67)	(102.33)	(17.10)	2.60
ICMA-95444	-0.82**	-0.61**	-0.18	-11.00**	-0.35	-0.04
	(43.00)	(4.17)	(73.33)	(100.00)	(17.92)	2.13
ICMA-95555	-1.82**	-3.11**	-1.18	-0.96	0.02	-0.27**
	(46.33)	(6.13)	(76.33)	(98.67)	(17.42)	2.40
RMS-3A	-2.71**	-0.31	-2.07*	7.88**	0.12	-0.06*
	(45.33)	(7.67)	(75.67)	(150.00)	(17.73)	(2.70)
SE±	0.19	0.21	1.03	1.04	0.27	0.03
Tester						
RIB-20K-86	0.04	2.26**	-1.31**	-3.74**	-1.55**	0.47**
	(48.00)	(10.07)	(78.00)	(157.67)	(19.50)	(1.50)
RIB-3135-18	-122**	-1.95**	-0.51	1.31	0.89**	-0.25**
	(48.66)	(4.87)	(78.67)	(104.33)	(12.51)	(2.50)
RIB-335-74	1.18**	0.31*	1.82**	2.43**	0.65**	-0.21**
	(46.33)	(7.03)	(76.33)	(135.00)	(13.09)	(1.60)
SE±	0.14	0.15	0.73	0.73	0.19	0.02

*Significant at 5% level, **Significant at 1% level, Data in parenthesis is per se performance.

effects in the desirable direction for 50% flowering, grain yield/plant, plant height and ear length. This hybrid also manifested that highest per se performance for all traits except grain yield. It is thus evident that this hybrid is most desirable under rainfed condition. The nonsignificant s.c.a. effects for hybrid RMS-3A×RIB-3135-18 is obvious and both the lines have almost similar lineage. Hence these are expected to have less variability, which is reflected in to non significant s.c.a effects. Three other hybrids namely; ICMA-95444×RIB-3135-18, ICMA-96111×RIB-20K-86 and ICMA-93333×RIB-335-74 had higher per se performance and significant s.c.a. effects for grain yield. The hybrid ICMA-95444×RIB-3135-18 had also significant s.c.a. effects for 50% flowering and productive tillers and ICMA-96111×RIB-20K-86 significant s.c.a. effects for productive tillers.

The selected hybrid, ICMA-93333×RIB-3135-18(based upon the per se performance and s.c.a. effects) has shown

Table 2. Specific combining ability effects and per se performance of hybrids

Parents	50% Flowering	Grain yield/plant (g)	Days to maturity	Plant height (m)	Ear length (cm)	Productive tillers (no./plant)
ICMA-93333x	0.67*	-3.93**	0.18	11.85**	0.70	-0.29**
RIB-20K-86	(47.33)	(12.67)	(77.67)	(193.00)	(27.89)	(1.00)
ICMA-93333x	0.40	2.90**	1.64	-0.90	0.26	0.49**
RIB-3135-18	(48.33)	(23.71)	(78.33)	(175.22)	(25.62)	(2.50)
ICMA-93333x	-1.07**	1.03**	-1.82	-10.95**	-0.96*	-0.20**
RIB-335-74	(48.00)	(19.27)	(78.00)	(171.33)	(25.92)	(1.10)
ICMA-96111x	0.78**	5.53**	3.40*	-13.41**	-2.57**	0.43**
RIB-20K-86	(48.67)	(19.48)	(78.67)	(171.97)	(27.11)	(1.90)
ICMA-96111x	-0.16	6.60**	-5.47**	2.58*	2.36**	-0.56**
RIB-3135-18	(49.00)	(11.56)	(69.00)	(182.91)	(29.56)	(1.70)
ICMA-96111x	-0.62*	1.08**	2.07	10.83**	0.16	0.12*
RIB-335-74	(49.33)	(16.47)	(79.67)	(197.34)	(29.56)	(1.70)
ICMA-95444x	-0.78**	-3.17**	-1.49	-7.35**	-0.62	-0.04
RIB-20K-86	(43.00)	(9.48)	(73.00)	(162.88)	(27.35)	(1.10)
ICMA-95444x	-2.38**	3.39**	-1.02	-7.52**	0.48	0.11*
RIB-3135-18	(42.66)	(20.24)	(72.67)	(157.67)	(26.01)	(2.00)
ICMA-95444x	3.16**	-0.22	2.51	14.47**	0.13	-0.08
RIB-335-74	(49.33)	(14.07)	(79.33)	(186.23)	(27.86)	(1.10)
ICMA-95555x	-0.11	-0.22	-0.82	-5.27**	0.45	0.05
RIB-20K-86	(42.66)	(9.95)	(72.67)	(175.00)	(28.79)	(1.00)
ICMA-95555x	2.62**	0.47	3.98**	8.24**	-2.11**	-0.20**
RIB-3135-18	(46.67)	(14.13)	(76.67)	(183.46)	(23.79)	(1.50)
ICMA-95555x	-2.51**	-0.27	-3.16	-2.96**	1.66**	0.15**
RIB-335-74	(42.67)	(11.53)	(72.67)	(178.43)	(29.76)	(1.10)
RMS-3Ax	-0.56*	-1.78**	-1.27	14.18**	1.99**	-0.16**
RIB-20K-86	(41.33)	(14.72)	(71.33)	(203.28)	(30.43)	(1.00)
RMS-3Ax	-0.49	-0.15	0.87	-2.39*	-1.00**	-0.16**
RIB-3135-18	(42.67)	(17.00)	(72.67)	(181.67)	(25.00)	(2.00)
RMS-3Ax	-1.04**	-1.63**	0.40	-11.79**	-1.00**	0.00
RIB-335-74	(45.33)	(12.96)	(75.33)	(178.44)	(27.20)	(1.20)
SE±	0.27	0.30	1.46	1.47	0.38	0.15

*Significant at 5% level, **Significant at 1% level, Data in parenthesis is per se performance.

its superiority in Initial Hybrid Trial (Kharif-2000). This hybrid produced higher grain yield, fodder yield and productive tiller, over the checks and has got third, six and second rank, respectively (Table 3). This medium maturing hybrid has recommended for the evaluation under Advance Hybrid Trial.

Table 3. Performance of Pearl millet Hybrid ICMA-9333×RIB-3135-18 (RHB-127) under Initial Hybrid Trial-2000 (Zone - A)

Characters	No. of location	RHB-127	Pusa-23	HHB-67	7686	Pusa-605	ICMH-356
Grain yield (kg/ha)	19	2830	2240	2136	2331	2331	2118
		(3)[1]	(30)	(32)	(26)	(25)	(33)
Fodder yield (q/ha)	19	60	47	47	46	51	44
		(14)	(30)	(31)	(32)	(28)	(35)
Days to 50% flowering	18	47	47	42	50	48	48
		(6)	(4)	(1)	(18)	(11)	(12)
Days to maturity	18	76	75	72	78	76	77
		(6)	(3)	(1)	(18)	(10)	(13)
Productive tiller	19	2.6	2.2	2.5	2.1	2.2	2.1
(No./plant)		(2)	(19)	(4)	(27)	(22)	(31)
Downy mildew %		4.7	0.0	2.5	5.7	3.7	2.3
at dough stage		84.6*	79.4*	79.4*	79.4*	79.4*	79.4*

[1] Data in parenthesis in rank, *Downy mildew % in Infector row

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QUANTITATIVE LOSSES IN THE VARIOUS KERNEL FRACTIONS DUE TO KHAPRA BEETLE *TROGODERMA GRANARIUM* EVERTS IN STORED MAIZE

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ABSTRACT

In all the varieties tested except Basi local maximum per cent loss caused by khapra beetle, *Trogoderma granarium* was in embryo fraction followed by pericarp and endosperm. Madhuri had the highest per cent loss in all fractions. Differential feeding of khapra beetle is dependent to some extent on the varieties. Loss of seed on dry weight basis were maximum in Madhuri followed by Basi local and NLD composite, hence placed in most susceptible group. The per cent loss ranged from 10.31 to 78.07 in embryo, 2.84 to 67.32 in endosperm and 1.27 to 62.14 in pericarp. This further proved and indicated that khapra beetle is primarily a germ feeder, thus causing great loss to nutritional value of stored maize.

Key words : *Trogoderma granarium*, maize, losses, embryo, pericarp, oil.

The maize grains during storage are damaged by different storage pests, among which khapra beetle, *Trogoderma granarium*. Everts is one of the important storage pest in hotter and drier parts of the world (Bains *et al.* 1976, Bhattacharya *et al.* 1982 and Viljoen 1990). *T. Granarium* posses a real threat to safe storage of maize grains (Champ and Dyte 1977). The first work on varietial resistance of some maize varieties to *T. Granarium* was accomplished by Punj (1970). Saxena and Vir (1977) determined the losses caused by *T. Granarium* and revealed that the weight loss was maximum (10.2 per cent in wheat, 18.2 per cent in bajra and 12.4 per cent in maize) at 90 per cent humidity but there was loss of only 2.7 per cent in maize at a very low RH of 5 percent. Maize is a valuable and less expensive source of protein, carbohydrates, vitamin B and some minerals.

Jood *et al.* (1992 and 1996) reported that *T. granarium* was comparatively more destructive than *R. dominica* because of the feeding habit of the insect. This magnitude of loss in stored maize by *T. granarium* is due to its nature of preferential feeding on the germ portion followed by endosperm and pericarp of the grain and thus causes great economic loss both in quantity and quality. Information in terms of the amount of losses caused by khapra beetle in different fractions of maize grains due to *T. granarium* in stored corn is the subject of present study.

MATERIALS AND METHODS

Stock culture of khapra beetle, *T. granarium* was maintained at 35 ± 1°C and 70 ± 2% R.H. in susceptible variety Basi local. Sixteen varieties of different susceptibility were selected for assessment of losses in different kernel fractions (Paudel *et al.* 2003). Grains of all varieties under test were cleaned from foreign materials and broken grains and sterilized at 60°C for 4 hours and cooled overnight at room temperature. The next day, maize grains were kept in desiccator in which 70±2 per cent relative humidity was maintained by dissolving requisite quantity of KOH in distilled water (Soloman, 1951). Then the grains were allowed to remain in disicator for 15 days to equilibrate the moisture content of different maize varieties at $\geq$ 14.0 per cent. The conditioned grains of different maize lines were then used for experiments purpose.

For inoculation, pupae of khapra beetle obtained from the stock culture were transferred to separate petri-dishes (10 cm in diameter) kept in BOD incubator and examined twice a day for adult emergence. Freshly emerged beetles (0-12 hrs. old) were sexed on the basis of size and antennal characters under a binocular (Halstead, 1963). There were six replicates each having twenty grains. Three replicates of each variety after inoculation with five pair of adults (0-12 hrs old) were kept in BOD at 35 ± 1°C and 70 ± 2% R.H.

Remaining three un-innoculated replicates were also kept at similar conditions. After 60 days the healthy and infested kernels of each variety were weighed and then soaked in distilled water for three hours after removing different stages of insects and frass. The various kernel fractions i.e. pericarp, embryo and endosperm were separated by dissecting them. Each fraction was dried in incubator at 110°C for one hr. in moisture cups. They were then cooled in desiccators and weighed. The process was repeated till constant weight was obtained. From the dry weight of kernel fraction in healthy un-infested and infested kernels, the percentage reduction in weight in each fraction due to insect feeding was calculated. Per cent reduction in whole seed on dry weight basis was also measured as described above.

RESULTS AND DISCUSSION

The damage caused by *T. granarium* to different fractions of the grain vary in different maize varieties. The quantitative losses in different kernel fractions viz. (i) pericarp (ii) embryo, (iii) endosperm; studied on dry weight basis in sixteen maize varieties are presented in Table 1.

The overall picture of damage to different kernel fractions in 16 maize varieties showed that in all varieties tested it was highest in embryo followed by pericarp and endosperm except Basi local where the loss in endosperm was slightly more than in embryo. The average per cent loss in embryo fraction in all the test varieties varied from 10.31 to 78.07 per cent. Present findings are in agreement with the findings of Hamed *et al.* (1992) who described that *T. granarium* prefers feeding on embryo causing great loss both in quantity and germination. Losses in different fractions of Madhuri, viz., embryo, endosperm and pericarp had an average per cent loss of 78.07, 67.32 and 62.14, respectively. This might be the reason that sweet corn is more preferred by *T. granarium* than other varieties due to its superior nutritional value. This indicated that the preferential feeding on different fraction of kernel is the function of nutritional value of maize varieties.

The losses in the pericarp were observed more than endosperm in all the varieties except Basi local, Prabhat, Trishulata and Madhuri, where the losses in endosperm were slightly higher than the pericarp. Giga *et al.* (1991) while working with S. zeamais reported that pericarp plays an important role in resistance. In present study losses in pericarp portion were maximum in variety Madhuri (62.14) and did not different significantly with NLD composite. The least loss was in Prabhat (1.27) which did not differ significantly from D 765 (7.6) and Ageti-76 (7.99). On the basis of observation it was concluded that varieties with thick pericarp were found to offer more physical resistance to the insect than those with thin pericarp as maximum dry weight of pericarp was recorded in variety Prabhat. Giga *et al.* (1991) reported that thick pericarp plays an important role in resistance in maize. He suggested that removing the pericarp increases the susceptibility in maize seeds.

Losses in endosperm fraction of sixteen maize varieties ranged from 2.84 (Ageti-76) to 67.32 per cent (Madhuri). Madhuri differed significantly from rest of the varieties. The other susceptible varieties with higher per cent loss in endosperm were Basi local and NLD composite and did not differ significantly from each other. These three varieties comprised the most susceptible group with regards to losses in endosperm. One interesting thing observed from this experiment was that *T. granarium* preferred pericarp fraction. This si probably due to the fact that endosperm of sweet corn possessed more nutrition then rest of the varieties.

Quantitative losses in entire seed on dry weight basis revealed that maximum loss was observed in variety Madhuri followed by NLD composite and Basi local. Madhuri was significantly different from rest of the varieties tested. The other two varieties NLD composite and Basi local were statistically at par and differed significantly from all the remaining varieties. So these varieties were considered as the most susceptible. On the other hand minimum per cent loss was observed in Ageti-76 (4.42), which did not differ significantly from AEB(Y) (6.03). AEB(Y) was also at par with varieties Prabhat (7.29), D765 (10.72), Trishulata (11.91), BH 1527 (12.0) and Ashwini (12.72). So these varieties considered relatively resistant. Percent loss on dry weight basis in entire seed in remaining varieties ranged from 14.33 to 18.48, comprised susceptible group. Kurdikeri *et al.* (1993) reported an average percent weight loss due to S. oryzae and R. dominica in different 5 maize hybrids ranging from 4.0 (minimum) in Ganga safed-2 to 27.7 (maximum) in Ganga 11. Goyal and Marwaha (1994) also reported an average per cent weight loss on dry weight, basis ranging from 23.39 to 36.81 due to *R. dominica* in five different maize varieties.

Based on the data obtained in losses in entire seed and on different kernel fraction

Table 1. Percent loss on dry weight basis in entire seed and different kernel fractions

Varieties	Grain status	Weight of 20 seeds (g)		% loss on dry wt. basis	Kernel fractions on dry weight basis					
		Initial	Dry		Pericarp	Loss %	Embryo	Loss%	Endosperm	Loss%
Amber popcorn	H	2.963	2.557	18.73	0.233	18.45	0.306	30.39	2.018	16.99
	I	2.460	2.078	(25.52)	0.190	(24.91)	0.213	(32.930)	1.675	(24.20)
Win popcorn	H	2.820	2.389	15.86	0.224	44.19	0.240	46.25	1.925	8.77
	I	2.345	2.010	(23.087)	0.125	(42.537)	0.129	(41.153)	1.756	(16.21)
AEB (Y)	H	5.804	5.074	6.03	0.389	8.99	0.611	13.58	4.074	4.61
	I	5.416	4.768	(14.160)	0.354	(6.857)	0.528	(21.030)	3.886	(12.253)
Ageti-76	H	5.912	5.245	4.42	0.413	7.99	0.585	15.04	4.257	2.84
	I	5.580	5.013	(8.487)	0.380	(16.00)	0.497	(22.477)	4.136	(8.5)
Prabhat	H	6.517	5.676	7.29	0.550	1.27	0.737	10.31	4.389	7.54
	I	5.995	5.262	(15.307)	0.543	(6.507)	0.661	(16.507)	4.059	(15.553)
Surya	H	6.329	5.594	14.33	0.457	13.1	0.666	20.27	4.471	13.57
	I	5.421	4.792	(22.25)	0.397	(19.19)	0.531	(26.690)	3.864	(21.527)
D 765	H	5.711	4.623	10.72	0.276	7.6	0.80	37.08	3.867	7.68
	I	4.690	4.127	(18.970)	0.255	15.043	0.302	(37.883)	3.570	(15.873)
Dhawal	H	6.258	5.557	18.48	0.456	23.2	0.701	37.9	4.400	14.9
	I	4.690	4.530	(27.08)	0.350	(28.58)	0.435	(36.60)	3.745	(21.807)
Trishulata	H	6.778	5.885	11.91	0.367	9.80	0.707	14.6	4.811	11.7
	I	5.964	5.184	(19.65)	0.331	(17.113)	0.604	(19.797)	3.747	(17.767)
BH 1527	H	5.207	4.652	12.00	0.428	10.7	0.542	46.7	3.682	7.1
	I	4.647	4.093	(19.77)	0.382	(19.257)	0.289	(43.073)	3.422	(12.837)

Contd...

Table 1 contd...

DHMDHM-103	H	5.322	4.631	18.72	0.300	34.0	0.632	53.8	3.699	11.5
	I	4.244	3.764	24.57	0.198	35.767	0.292	47.153	3.274	19.507
Ashwini	H	5.685	5.024	12.72	0.363	19.83	0.622	29.90	4.039	9.43
	I	4.948	4.385	20.608	0.291	26.223	0.436	32.873	3.658	17.40
Madhuri	H	2.858	2.280	69.07	0.391	62.14	0.573	78.07	1.316	67.32
	I	1.019	0.706	56.1	0.148	51.957	0.128	62.157	0.430	54.843
Basi local	H	3.303	2.922	41.99	0.160	30.62	0.318	40.88	2.444	42.88
	I	2.013	1.695	40.180	0.111	33.420	0.188	39.303	1.396	39.980
LM-5	H	5.464	4.543	14.73	0.326	37.1	0.470	46.80	3.747	12.70
	I	4.273	3.726	25.13	0.205	37.737	0.250	43.26	3.271	20.903
NLD	H	4.401	3.864	45.28	0.230	61.73	0.500	74.40	3.134	39.43
composite	I	2.4161	2.114	42.23	0.088	51.690	0.128	57.37	1.898	38.9
Sem				2.253		3.106		4.201		3.364
C.D. at 5%				6.695		9.227		12.482		9.995
C.D. at 5%				9.171		12.640		17.099		13.691

Figure within parenthesis are angular transformed values those without bracket are original values

H = Healthy uninfected I = Infested

(Table 1) it is evident that irrespective of the varieties under observation, the maximum per cent loss was recorded in embryo fraction followed by pericarp and endosperm. In case of Basi local the per cent loss was maximum in endosperm fraction followed by embryo and pericarp. De and Sarup (1989) reported maximum loss in endosperm fraction of maize due to the feeding by *S. oryzae*. This may be due to the fact that the larva of *S. oryzae* is internal feeder and devours endosperm completely before coming out of the grain in adult form. Present findings suggests that development of khapra beetle larvae caused maximum loss of embryo, thus affecting germination adversely and causing great loss to oil content. Suitable and eco-friendly management schedule is the need of hour to save stored maize against this pest.

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BIOLOGY OF MUSTARD APHID, *LIPAPHIS ERYSIMI* (KALT.) ON DIFFERENT *BRASSSICA* GENOTYPES UNDER LABORATORY CONDITIONS

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ABSTRACT

Laboratory study on biology indicated that mustard aphid, *Lipaphis erysimi* Kaltenbach passed through four nymphal instars. The total nymphal period varied from 8.19 to 9.45 days. The pre-reproductive, reproductive and post-reproductive periods were 1.25 to 1.53, 14.33 to 17.20 and 2.40 to 2.64 days, respectively. The adult longevity was 13.53 to 16.77 days. The daily fecundity varied from 4.93 to 6.02 nymphs per female per day.

Key words : Biology, nymphal instar, *Lipaphis erysimi.*

The mustard aphid, *Lipaphis erysimi* Kalt. is a major pest ubiquitous in mustard growing region of the world. Severe incidence of aphid during reproductive stage of mustard resulted in severe loss in seed yield (Suri *et al.* 1988). Biology of this pest so far has not been studied under semi-arid region of eastern Rajasthan. This paper discusses biology of *L. erysimi* on different *brassica* genotypes under laboratory condition.

MATERIALS AND METHODS

The biology of mustard aphid, *L. erysimi* on five promising brassica genotypes was carried out under laboratory conditions. The second or third leaf along with petiole from the top of the plant were plucked from each genotype and brought to the laboratory in separate polythene bags. The petioles of each leaf was wrapped in water soaked absorbent cotton wool swap separately, to keep the leaf turgid. The gravid mustard aphids were collected from five genotypes separately from unprotected set. One female from respective genotype was released on each leaf in a separate specimen tube. These specimen tubes covered with muslin cloth fastened with rubber bands and were replicated five times. Next day all newly borne nymphs (one day old) except one female were removed. The leaves were changed daily in the morning hours during the entire period of study. Aphids were transferred from one leaf to another with the help of camel hair brush. The change of instar was considered on the presence of exuviae-casted by the nymph. The duration of each different instar, longevity and fecundity were recorded on different *brassica* genotypes. Measurement of each instar and apterous females was recorded with an occular micrometer after calibrating it with a stage micrometer and the mean values were calculated.

RESULTS AND DISCUSSION

Size of nymphs and adults

The laboratory study on size of nymphs and adults indicated that *L. erysimi* passed through four nymphal instars. First instar nymph was wingless, delicate, transparent, oval in shape and yellowish green in colour. It measured 0.56 to 0.67 mm (av. 0.61±0.07) in length and 0.26 to 0.35 mm (av. 0.30±0.03) in width. Second instar nymph was greenish yellow in colour and measured 1.04 to 1.17 mm (av. 1.10±0.04) in length and 0.50 to 0.64 mm (av. 0.57 ± 0.05) in width. Third instar nymph was similar to second instar nymph except in size. It measured 1.23 to 1.45 mm (av. 1.34 ± 0.05) in length and 0.59 to 0.72 m (av. 0.65±0.02) in width. Fourth instar nymph was light greenish yellow having roundish abdomen. It measured 1.49 to 1.67 mm (av. 1.58 ± 0.07) in length, while the width ranged from 0.73 to 0.89 mm (av. 0.81 ± 0.05).

The apterous female

It looked more or less like fourth instar nymph. It had well developed abdomen which was more roundish at the terminal end than that in nymphal instars. The antennae were fairly long having seven clearly visible segments. The cornicles were prominent, long, tubular dark brown to black in colour. The length of the adult varied from 1.81 to 2.29 mm (av. 2.05±0.18), while the width ranged from 1.07 to 2.29 mm (av. 2.05±0.18), while the width ranged from 1.07 to 1.14 mm (av. 1.10±0.08). More or less similar external features and size of nymphal instars and adult mustard aphid had been reported by Patel (1980) and Vekaria and Patel (1999).

Duration of various stages

Nymph

The duration of all nymphal instar varied from 1 to 3 days on each of the five genotypes of *brassica* (2 from *B. juncea* and 1 each from *B. campestris*, *B. napus* and *B. carinata*). The average duration of all nymphal instars varied from 1.46 to 1.86, 1.80 to 2.13, 2.13 to 2.73 and 2.67 to 3.00 days, respectively in the first, second, third and fourth instars (Table 2). Thus, total duration of nymphal instars varied with non-significant differences between 8.19 days (Kranti) to 9.45 days (Varuna) having no impact of test genotype. The duration of different nymphal instars were comparable with similar observation reported by Patel (1980) and Vekaria and Patel (1999).

The pre-reproductive period varied significantly among the different genotypes, being minimum (1.25 days) on HC-2 and maximum (1.53 days) on Kranti. The reproductive period differed significantly in *Brassica genotypes* confirming the findings of Rohilla *et al.* (1993). It was minimum 14.33 days on Varuna as against maximum of 17.20 days on R-15. Likewise, post reproductive period and adult longevity was lower on Varna (*B. juncea*). These three life stages ultimately affected the average life span of mustard aphid, being lower on R-15 (23.06 days) a susceptible and higher on resistant host Varuna (26.96 days). Earlier, Kalra *et al.* (1987), Dilawari and Dhaliwal (1988), Singh *et al.* (1996) and Agarwal *et al.* (1996) reported that (*B. tournifortii*, *B.*

Table 1. Size of nymphs and adult of *L. erysimi*

Stage	No observed	Length (mm)			Width (mm)		
		Minimum	Maximum	Average ± S.D.	Minimum	Maximum	Average ± S.D.
Nymph							
I Instar	30	0.56	0.67	0.61±0.07	0.26	0.35	0.30±0.03
II Instar	30	1.04	1.17	1.10±0.04	0.50	0.64	0.57±0.05
III Instar	30	1.23	1.45	1.34±0.05	0.59	0.72	0.65±0.02
IV Instar	30	1.49	1.67	1.58±0.07	0.73	0.89	0.81±0.05
Adult							
(Apterae)	30	1.81	2.29	2.05±0.18	1.07	1.14	1.12±0.08

Table 2. Biology of *L. erysimi* (Kalt.) on different *brassica* genotypes under laboratory conditions

Species/genotype	Duration (days)										Average fecundity	
	Nymphal instar 1st	2nd	3rd	4th	Total nymphal period	Pre-reproductive period	Reproductive period	Post-reproductive period	Average adult longevity	Average life span	Per female	Nymph/ female/ day
B. juncea												
Varuna	1.73	2.06	2.66	3.00	9.45	1.26	14.33	2.40	13.53	26.96	78.73	4.93
Kranti	1.46	1.80	2.13	2.80	8.19	1.53	15.93	2.53	14.06	26.40	80.67	5.06
B. campestris												
BSH-1	1.86	2.13	2.73	2.93	9.65	1.37	16.33	2.64	16.20	25.62	85.13	5.21
B. napus												
R-15	1.80	1.96	2.34	2.84	8.94	1.29	17.20	2.53	16.77	23.06	103.67	6.02
B. carinata												
HC-2	1.77	1.93	2.21	2.67	8.58	1.25	16.96	2.57	16.65	24.80	96.53	5.69
SEm±	-	-	-	-	-	0.04	0.45	-	0.57	0.60	4.30	0.25
C.D. (5%)	NS	NS	NS	NS	-	0.10	0.15	NS	1.49	1.69	12.65	0.62

nigra, B. juncea) were resistant to mustard aphid infestation at various locations in India. The present findings are in accordance with the above findings.

Fecundity per female was also more on susceptible cultivars, i.e. 103.67 nymphs/female on R-15 and 96.53 nymphs/female on HC-2. However, minimum fecundity of 78.73 nymphs/female was observed on Varuna which was at par with Kranti (80.67 nymphs/female) and BSH-1 (85.13 nymphs/female). Average fecundity/female/day was significantly less, i.e. 4.93 nymphs/female/day on Varuna to a maximum of 6.02 and 5.69 nymphs/female/day on R-15 and HC-2, respectively. Post-reproductive period varied between 2.40 to 2.64 days being lower on resistant cultivars. These findings further supported the view that resistant cultivars had antibiotic effect on the development of mustard aphid in the form of reduced reproductive period, adult longevity and total fecundity.

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IMPACT OF GROWTH HORMONES ON GERMINATION OF SUGARCANE

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Sugarcane is one of the most important global cash crop of tropical and subtropical regions. India is the largest country with area under cultivation (3.81 m ha) of sugarcane and 217.21 m tonnes in cane production. Hence, it occupies an important place in the national economy and fundamentally affects to the socio-economic life of the rural massage. The present study is based on the germination in new technology adopted by cane growers run with the help of sugar industries i.e., Polybags technique carrying the seed buds treated by growth hormones 1.0% solution. The main aim has been to analyse the impact of growth hormones on germination of sugarcane varieties.

The study was conducted in mid Feb. 1999 at Research and Development Centre, Triveni Engineering & Industries Ltd., Khatauli on five most popular sugarcane varieties viz., CoJ-64, CoS-8432, CoS-8436, CoS-88230 & CoP-84212 were largely planted in Western U.P. The seed buds have been treated by 1.0% solution of growth hormones GA_3+α-N.A.A. and Banglol-6 upto 30 minutes. After treatment, seed buds were planted in polybags before air dry. Each variety having hundred polybags with treated and untreated buds equally numbers. The germination were observed daily and irrigation maintained as per requirement of trial. The polybags situated in open and uncontrolled environmental conditions.

The present experiment differentiates three characteristic phases in all the 5 varieties during a period of 35 days. On the 10th day, the growth observed in treated plants has been 26.0% to 9.0% maximum for CoP-84212 followed by CoS-8432 (9.0%). At 18th day i.e., with an interval of 8 days, the growth in treated plants enhanced by 64.10% to 45.6% and growth succession changes to maximum 64.10% (CoS-8436), 57.55% (CoS-8432), 52.25% (CoP-84212), 49.25% (CoS-88230) and 45.60% (CoS-88230), 6.1% (CoS-84212), 3.15% (CoS-8436) and 1.57% least in CoS-8432 (Table 1). Hence, it is interesting to note that the maximum growth period correlated with the prevailing weather conditions in the month of February, 1999 has been during 10th to 18th day after planting the crop whereas period between 18th to 35th day seems to be the maintenance phase, perhaps where hormones losses its potentiality.

Beneficial effect of growth regulating chemicals on cane yield was also recorded by Sundra and Thirupal (1994). The use of biozyme and cytozyme on sugarcane were also reported and discuss the good results by Pol & Deshmukh (1995) and Mathan

(1997), respectively. Comparing the control values without hormonal treatments, the growth recorded during the 3rd phase have been maximum for variety CoP-84212 (65.15%), 63.71% (CoS-8432), 61.90% (CoS-8436), 48.77% (CoJ-64) and 46.15% (CoS-88230) and much lower than the treated plants.

The present study thus concludes that the growth hormones GA_3 has positive impact over the germination of the sugarcane with maximum germination in variety CoS-8436 followed by CoS-8432, CoP-84212, CoS-88230 and least in CoJ-64 during 10th to 18th days after planting the buds in polybags.

It may be concluded that the above discussion of growth rate at the time of germination in sugarcane crop with significantly increased by the application of growth hormones. Germination was analysed 1.29 to 1.41 times more as compared to control in all the sugarcane varieties with the highest percentage in CoS-8436. Therefore, it is suggested that all sugarcane growers treated the cane seed at the time of planting. It will be more beneficial to the farmers particularly in Western U.P. where sugarcane is commonly late sowing after wheat harvesting and it more consequently for multiplication of new promising varieties.

Table 1. Effect of growth hormone on germination

Days	Variety-wise germination percentage									
	CoS-8436		CoS-88230		CoJ-64		CoS-8432		CoP-84212	
	T	C	T	C	T	C	T	C	T	C
10	20.00	-	9.00	-	18.00	-	24.00	-	26.00	-
12	60.49	-	19.74	-	58.33	-	68.58	-	70.73	-
14	80.00	-	39.74	-	60.87	-	78.64	-	75.61	-
16	83.95	-	51.31	-	62.50	-	81.55	-	78.05	-
18	84.10	-	58.25	-	63.60	-	81.55	-	78.25	-
20	85.00	52.38	60.50	26.92	65.22	28.02	81.59	44.91	79.27	39.66
22	85.80	57.14	61.50	30.77	68.35	32.66	81.95	57.45	81.70	44.77
24	85.80	60.90	62.00	38.46	70.00	41.33	82.00	63.45	82.35	52.14
35	87.25	61.90	65.00	46.15	73.02	48.77	83.12	63.71	84.35	65.15

T = Treated, C = Control

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GROWTH AND YIELD OF CABBAGE (*BRASSICA OLERACEA VAR. CAPITATA LINN.*) AS AFFECTED BY DIFFERENT NITROGEN LEVELS

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An experiment was conducted on cabbage (cv. Express) at Horticulture Farm of S.K.N. College of Agriculture, Jobner during rabi 1997-98. This area falls under semi-arid region characterized by extremes of temperature both in summer and winter. The soil type is sandy loam containing total nitrogen (0.026%), available nitrogen (109.25 kg/ha), phosphorus (21.60 kg/ha), potash (134.50 ppm), pH 8.4, EC 2.29 mmhos/cm at 25°C etc. Cabbage is one of the most economically important member of genus Brassica. In India, it ranks next to cauliflower in area and production. Among the cabbage cultivars, "Express" is most popular because of tis quality heads. Cabbage is a geacy feeder and requires adequate manuring for profitable yields especially nitrogen, which is a costlier input so it is essential to use this input very cautiously and economically. Keeping in view the lack of informaiton to the nitrogen requriement of cabbage in India, the present experiment was undertaken with objective to find out optimum dose of nitrogen for its maximum growth and yield. The experiment was laid out in a randomized block design with four replications with three levels of nitrogen viz., N1 (100 kg/ha), N2 (125 kg/ha) and N3 (150 kg/ha). During fertilization a basal dose of phosphorus (60 kg/ha) and potash (60 kg/ha) were drilled in the form of superphosphate and muriate of potash, respectively, and half dose of each of three levels of nitrogen (100 kg, 125 kg, 150 kg/hectare) were applied at the time of transplanting, one fourth of total nitrogen was applied after 20 days of transplanting and remaining one fourth at the time of head formation. Being a transplanted crop, seedlings were grown on a well prepared beds of 2 × 1 meter size and transplanting was done after six weeks at height of 4.5 cm. The distance between row to row was kept 45 cm and plant to plant was 30 cm, 45 cm and 60 cm). Ten plants were randomly selected in each plot and were tagged for recording, observations and their averages were calculated. Periodical observations were recorded after one month of transplanting.

Table 1 reveals that there was significant increase in plant height (cm) at all three stages by the application of nitrogen levels. The dose N3 (150 kg ha^{-1}) recorded maximum at 30 DAT as compared to N2 (125 kg ha^{-1}) and N1 (100 kg ha^{-1}). However, N1 and N2 were statistically at par. Number of leaves significantly increased with increasing levels of nitrogen at 30 DAT, 60 DAT and harvest. The per cent increase in number of leaves at 30 DAT, 60 DAT and harvest were 24.37, 31.19 and 19.74 per cent respectively, over N1 treatment. Stem diameter (cm) increased with increasing levels of nitrogen at 45 DAT and also at harvest. AT 45 DAT, the level of nitrogen N_2 (125 kg ha^{-1}) could significantly increased the stem diameter which was 10.81 per cent more as compared to N_1 (100 kg ha^{-1}), however, N_3 and N_2 were statistically at par. Similarly at harvest, maximum stem diameter (1.308 cm) was observed with the treatment N_3 followed by N_2 (1.150 cm) and N_1 (0.962 cm). The per cent for increasing with N_3 as compared to N_1 being 35.97 at harvest. Leaf area was significantly increased with the increasing levels of nitrogen at 45 DAT and also at harvest. With the application of 150 kg N ha^{-1} significantly increased the leaf area (289.00 cm^2) over 100 kg N ha^{-1} (271.41 cm^2) and 125 kg N ha^{-1} (282.91 cm^2). However, N_2 and N_3 were statistically at par to each other. The same trend was observed at harvest, N_3 (150 kg N ha^{-1}) recorded the maximum leaf area (324.16 cm^2) followed by N_2 and N_1. The present investigation has shown that increasing levels of nitrogen significantly increased the plant height, number of leaves per plant, stem diameter and leaf area (Table 1). This may be due to better nutritional environment in the root zone for growth and development of plant by the application of nitrogen. Nitrogen is main constituent of protoplasm, cell, nucleic acids, protein, chlorophyll and many other metabolic products. The present finding showing the significant effect of increasing levels of nitrogen and in close conformity with the findings of Mangal *et al.*, (1984) Sharma and Lal (1986).

The data presented in Table 1 revealed that there was significant increase in head weight with the increasing levels of nitrogen, viz., N_1, N_2 and N_3 (100 kg, 125 kg and

Table 1. Effect of different nitrogen level on plant height (cm), number of leaves/plant, stem diameter (cm), leaf area (cm^2), head weight (g), biological yield (q ha^{-1}), economic yield (q ha^{-1}), harvest index (%) at different growth stages

	Plant height			No. of leaves/plant			Stem diameter		Leaf area					
Nitrogen	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest	45 DAT	At Harvest	45 DAT	At Harvest	Head weight	Biological yield	Economic yield	Harvest Index
N_1 (100 kg ha^{-1})	8.80	12.72	17.45	6.03	11.51	15.55	0.583	0.962	271.41	301.25	731.66	361.57	251.19	69.45
N_2 (125 kg ha^{-1})	9.08	13.79	19.12	6.95	13.58	17.58	0.625	1.150	282.91	311.66	795.83	386.65	270.05	70.20
N_3 (150 kg ha^{-1})	9.71	15.04	20.29	7.50	15.10	18.62	0.646	1.308	289.00	324.16	859.91	414.09	296.63	71.64
SEm±	0.120	0.490	0.510	0.091	0.108	0.360	0.013	0.026	2.96	3.28	17.91	5.94	4.13	0.52
C.D. at 5%	0.368	1.450	1.490	0.265	0.314	1.050	0.039	0.077	8.64	9.54	52.13	17.20	12.03	1.51

DAT = Days after transplanting

150 kg N ha^{-1}), respectively. The maximum head weight (857.91 g) was recorded under N_3 followed by N_2 (795.83 g), while the minimum (731.66 g) head weight was recorded under N_1. The per cent increase in the head weight 917.25) under N_3 over N_1 levels of nitrogen. The maximum biological yield (414.09 q ha^{-1}) was recorded under N_3 followed by N_2 (386.65 q ha^{-1}), while the minimum (361.57 q ha^{-1}) was recorded under N_1. There was significant increase in economic yield with increasing levels of nitrogen. The maximum yield (296.63 q ha^{-1}) was recorded under N_3 while the minimum (251.19 q ha^{-1}) was recorded with N1. The per cent increase being 18.08 under N_3 level over the nitrogen level of N_1. There was significant increase in per cent harvest index with increasing levels of nitrogen. Maximum per cent harvest index (71.64) was recorded under N_3 (150 kg ha^{-1}) and minimum (69.45) was recorded at N1 (100 kg N ha-1). The increasing levels of nitrogen significantly increased the head weight, biological yield and economic yield (Table 1). This might be due to the fact that increased nitrogen supply resulted in more chlorophyll content, which together accelerated the photosynthetic rate and thereby increased the supply of carbohydrates. The better availability of nitrogen also favoured the metabolic and auxin activities in the plant and ultimately resulted in the increased vegetative growth and head weight than ultimately increased biological and economical yield at higher level of nitrogen (150 kg N ha-1). Similar results have also been reported by Freyman et al. (1991), Balyan and Singh (1994), Thankara et al. (1996) and Dixit (1997).

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AGRO-INPUT MANAGEMENT PRACTICES ON GROWTH, CHLOROPHYLL CONTENT AND GRAIN YIELD OF HYBRID RICE (*ORYZA SATIVA*)

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The hybrid rice in general produce higher grain yield than that of inbred rice due to vigour, better sink size and rooting system. The world wide problem of high sterility percentage in hybrid rice needs serious attention for accelerating the grain yield. The manipulation of agro-inputs may reduce sterility percentage and increase grain yield. Keeping these in view an attempt was made to asses the performance of various agro-inputs including scheduling of nitrogen on chlorophyll content, yield component and grain yield of hybrid rice at IGAU, Raipur, Chhattisgarh during *kharif* season of 2000.

The soil was clayey in texture having 0.48% organic carbon, 218 kg/ha available N, 19 kg/ha available P, 317 kg/ha exchangeable K and 6.9 pH. In all 12 treatments were laid out in randomized block design. The treatment were T_1 – N : 40% basal (B) + 25% active tillering (T) + 25% at panicle initiation (PI) + 10% at flowering, (F); T_2 – N : 50% (7 DAT) + 30% at PI + 20% at F; T_3 – N : 50% as B + 25 % at T + 25% at PI; T_4 – Urea of T_1 was blended with 14 days decomposed cowdung urine mixture (CDU) at the ratio of 1:6:1 (urea : cowdung : urine); T_5 - T_1 + 0.02 kg a.i. kg/ha lower concentration, (LC) of 2, 4-D, at maximum tillering (Max. T); T_6 - T_1 + micronutrient mixture @ 25 kg/ha at Max. T;T_7 - T_1 + Brassinolides (Double) @ 200 ppm at PI; T_8 - T1 + 2, 4-D @ 1.25 kg a.i./ha (higher concentration, HC) at PI only to lower leaves; T_9-T1 + GA3 @ 50g/ha (30 g/ha at Max. T and 20 g/ha at PI); T_{10} - T1 + Removal of lower leaves, leaving upper five leaves at PI; T_{11} - T1 + removal of all tillers after 10th tiller; T_{12} - T1 + foliar application of silica @ 20 kg/ha at PI. An uniform dose of 150:80:60 kg NPK/ha was applied to the crop. The whole amount of P and K was applied as basal dressing through single super phosphate and muriate of potash. The rice hybrid "Pro Agro 6201" was grown. The Chlorophyll content was analyzed by acetone extraction procedure (Yosida *et al.*, 1976).

Among the N schedules, application of N : 40%B + 25% T + 25% T + 10% F produced significantly higher grain yield than that of scheduling of N either 50% (7 DAT) + 30% PI + 20% F or 50% B + 25% T + 25% PI (Table 1). The significant increase in effective tillers, spikelets/panicle, fertile spikelets/panicle. LAI and chlorophyll content contributed for increased grain yield. The similar finding have been reported by Mahapatra *et al.* (1992). The reduced sterility percentage under earlier N schedule further enhanced the grain yield of hybrid

Table 1. Effect of agro-input management practices on leaf area index, chlorophyll content, yield attributing characters and grain yield of hybrid rice

Treatment	Effective tillers/m^2 (no.)	Panicle length (cm)	Spikelets/ panicle (no.)	Fertile spikelets (no.)	Sterility (%)	Test wt. (g)	Grain yield (q/ha)	Harvest index (%)	LAI at 60 DAT	Chlorophyll content in leaf at 60 DAT (mg/g)		
										'a' (mg/g)	'b' (mg/g)	Total (mg/g)
T1-N : 40% B + 25% T + 25% PI + 10% F	210	24.91	177.82	127.27	28.41	22.27	56.28	41.03	6.07	0.58	1.03	1.61
T2-N : 50% (7DAT)+ 30% PI + 20% F	201	24.00	171.38	120.59	30.56	21.38	49.47	41.32	5.86	0.44	0.77	1.21
T3-N : 50% B + 25% T + 25% PI	207	24.17	171.81	121.20	29.46	22.00	53.22	41.14	5.97	0.54	1.09	1.63
T4 - T1 + Urea blended with CDU	225	26.30	182.83	132.59	27.49	23.44	62.07	41.02	6.27	0.73	1.28	2.01
T5 - T1 + 2, 4-D (LC)	230	26.17	182.36	135.49	25.71	23.06	61.27	40.56	6.38	0.80	1.41	2.22
T6 - T1 + Micronutrients	232	27.00	183.857	135.78	26.16	23.96	62.56	40.65	6.46	0.88	1.54	2.42
T7 - T1 + Brassinolides	245	27.12	185.93	138.65	25.61	24.29	63.66	40.15	4.70	0.88	1.54	2.42
T8 - T1 + 2, 4-D (HC)	212	24.00	179.09	132.19	26.19	22.29	56.67	42.19	5.88	0.66	1.15	1.81
T9 - T1 + GA3	260	27.50	190.13	145.46	23.50	24.38	67.99	41.06	6.69	1.06	1.86	2.93
T10 - T1 + Removal of al leaves leaving top five leaves	218	25.19	181.41	137.59	24.12	22.50	59.08	43.47	0.51	1.00	1.75	2.75
T11-T1 + Removal of all tillers after tength tiller	215	25.01	179.75	134.52	25.16	22.27	57.78	46.75	3.30	0.93	1.63	2.56
T12-T1 + Sio @ 20 kg/ha as FS	220	25.91	183.77	139.35	24.17	23.06	59.95	40.25	5.26	0.80	1.41	2.23
C.D. at 5%	6.89	0.89	4.85	3.54	1.22	1.11	2.53	0.94	0.19	0.09	0.39	0.11

FS - Foliar spray, CDU - Cowdung urine

Table 2. Correlation matrix among, growth, yield component and grain yield of hybrid rice

Character	Total chlorophyll	Fertile spike-lets/panicle	Panicle length (cm)	Spikelets/ panicle	Sterility percentage	Test weight	Harvest index	LAI	Grain yield
Effective tillers/m^2	0.750**	0.823**	0.923**	0.905**	-0.652	0.941**	-0.237	0.308	0.938**
Total chlorophyll		0.905**	0.729**	0.861**	-0.926	0.703*	0.257	0.917**	0.829**
Fertile spikelets/panicle			0.784**	0.960**	-0.953	0.795**	0.0037	-0.103	0.904**
Panicle length (cm)				0.899**	-0.614	0.962*	-0.366	0.29	0.923**
Spikelets/panicle.					0.839	0.914**	-0.160	0.067	0.974**
Sterility percentage						-0.614	-0.189	0.326	-0.768
Test weight							-0.395	0.358	0.950**
Harvest index								-0.693	-0.210
LAI									0.180

*Significant at 5% level; **significant at 1% level rice. The application of brassinolides or micronutrients or 2, 4-D (LC) or urea treated with CDU alongwith N schedule of 40% B + 25% T + 25% PI + 10% F were comparable to each other for the panicle length, grains/panicle, test weight and grain yield. The application of brassinolides under said N schedule produced maximum LAI at 60 DAT. The agro-inputs i.e. urea blended with CDU, 2, 4-D (LC), micronutrients, brassinolides and GA3 applied along with N schedule of N : 40% B + 25% T + 25% PI + 10% F.

The application of GA_3 alongwith N schedule of 40% B + 25% T + 25% PI + 10% F found to be significantly superior to that of other treatments for effective tillers, grains/panicle, fertile grains/panicle and total cholorophyll content. The increase in these characters helped in increasing the grain yield. The GA_3 appeared to be involved not only in alteration of nucleic acid and directed protein syntheses (as in auxin) in long-term regulatory actions (Zhu, 1998). The correlation analysis also indicated a significant positive correlation among these characters towards grain yield except sterility percentage and harvest index (Table 2).

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EFFECT OF NITROGEN AND PLANT POPULATION ON YIELD COMPONENTS AND YIELD OF POPCORN VARIETIES OF MAIZE

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In India, the national average productivity of maize is only 1.785 tonnes/ha which is far behind the world average of 4.2 tonnes/ha. Popcorn, the common snack item is a special maize group characterized by short plant height with high nitrogen requirement. Crop yield is highly affected by variety, nitrogen and plant population. The importance of these vital factors led to determine their effect on yield components and yield of two released popcorn varieties viz., 'V.L. Amber popcorn' and 'Amber popcorn' in Delhi conditions.

The experiment on two popcorn varieties ('V.L. Amber popcorn', 'Amber popcorn') with three levels of nitrogen (50, 100, 150 kg N/ha) and three plant population levels (40×10^3, 65×10^3, 90×10^3 plants/ha) was conducted at experimental farm of Indian Agricultural Research Institute, New Delhi, during *kharif* 2000. The experiment was laid out in factorial randomized block design with 18 treatment combinations and 3 replications. N dose and plant to plant distance were varied according to the treatments, other inputs applied were same for all the treatments. The soil was sandy loam, low in available N, organic carbon and medium in available P and K with pH 8.0.

The shelling % and test weight was significantly higher for 'V.L. Amber popcorn' and it increased significantly with increasing N dose and decreased in case of higher plant population (Table 1). Similar results were obtained by Roy and Singh (1986) and Hassan (2000). This may be due to better growth, nutrient availability, resource utilization and effective translocation of photosynthates from source to sink.

'V.L. Amber popcorn' recorded significantly higher grain and stover yield over 'Amber popcorn'. The success of crop depend on the vegetative growth, harvesting of solar radiation and its storage as photosynthates and finally its proper translocation to the sink. Beside this, the quantity and quality of growth made by a plant are controlled to some extent by its genetic potentialities, apart from the effect of environment. In all these aspects, 'V.L. Amber popcorn' probably proved superior and hence produced higher yield over 'Amber popcorn'.

Grain yield and stover yield increased by 19.86% and 13.81%, respectively by increased N level from 50 kg N/ha to 100 kg N/ha but with further increase to 150 kg N/ha, the % increase in grain and stover yield was only 10.8% and 9.34%, respectively. Application of 100 kg N/ha increased the harvest index significantly from 0.29 at 50 kg N/ha to 0.30 which was at par with that of 150 kg N/ha (0.30). This may be due to beneficial effect of N at lower level on improving vegetative growth i.e.

source, yield contributing characters i.e., the sink and proper translocation of assimilates from source to sink. Similar effect of N on grain and stover yield was reported by Roy and Singh (1986), Hassan (2000) and Ibrahim (1997).

Increasing the plant population from 40×10^3 to 65×10^3 and further to 90×10^3 plants/ha increased grain yield by 19.14% and 4.07% respectively and increased stover yield by 50.54% and 14.46%, respectively. However, the harvest index decreased significantly from 0.34 at 40×10^3 plants/ha to 0.29 and 0.27 at 65×10^3 and 90×10^3 plants/ha, respectively. The initial increase in grain and stover yield may be attributed to increase in number of ears/ha and reduction in the rate of increase at higher level may be due to reduction in number of double bearing plants/ha, number of grains/ear, length and girth of ear, as well as test weight and enhanced number of barren plants due to the competition for light, space and nutrients. The decrease in harvest index may be due to the improportionate increase in stover yield as compared to grain production. Similar findings were reported by Tyagi et al. (1998) and Hassan (2000).

Table 1. Effect of nitrogen and plant population on yield ocmponents and yield of popcorn varieties

Treatment	Shelling%	Test wt. (g)	Grain yield* (q/ha)	Stover yield (q/ha)	Harvest index
Variety					
'V.L. Amber popcorn'	73.41	142.71	27.05	64.27	0.30
'Amber popcorn'	72.40	142.11	24.81	60.83	0.29
SEm±	0.04	0.09	0.10	0.21	0.003
CD at 5%	0.13	0.26	0.28	0.59	0.01
Nitrogen (kg/ha)					
50	71.14	138.29	22.05	55.48	0.29
100	73.29	143.44	26.43	63.14	0.30
150	74.28	145.50	29.30	69.04	0.30
SEm±	0.05	0.11	0.12	0.25	0.004
CD at 5%	0.15	0.32	0.34	0.72	0.011
Plant population ($x10^3$ plants/ha)					
40	74.87	148.34	22.67	44.38	0.34
65	72.60	144.50	27.01	66.81	0.29
90	71.24	138.39	28.11	76.47	0.27
SEm±	0.05	0.11	0.12	0.25	0.004
CD at 5%	0.15	0.32	0.34	0.72	0.011

* Grain yield measured at 15% moisture

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AGROTECHNIQUES TO IMPROVE THE PRODUCTIVITY OF PEARLMILLET + COWPEA INTERCROPPING SYSTEM UNDER DRYLAND CONDITIONS

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Pearlmillet is an important *kharif* crop in dryland areas. Its physiological adaptation i.e., drought escaping character owes high popularity among the farmers. Sowing of pearlmillet under dryland conditions solely depends on onset of monsoon. The optimum sowing time for pearlmillet is first fortnight of July. Delay in onset of monsoon is very common phenomenon in dryland conditions. Meena *et al.* (1998) reported a sharp decline in dryland i.e., 4 to 80 kg/ha/day under rainfed conditions. To compensate yield under late sown conditions, transplanting is the best remedy (Bhardwaj *et al.* 1960). It is because of three weeks old seedlings after transplanting produce more tillers and show better ear development resulting in higher yield (Bhatnagar *et al.* 1988). To further increase yield potential of pearlmillet + cowpea intercropping system, the method of pearlmillet establishment play a significant role.

Field experiments were conducted during 1999 and 2000 at the Indian Agricultural Research Institute, New Delhi. The design of experiment was split plot design, consist of four main plot treatments and 7 sub-plot treatments. Main plot treatments were sole pearlmillet direct seeded, direct seeded pearlmillet + cowpea, transplanted sole pearlmillet and transplanted pearlmillet + cowpea intercropping. The sub plot treatments consist of control, biofertilizer (*Azospirillum* + VAM), 20 kg N + 15 kg P_2O_5, 20 kg N + 15 kg P_2O_5 + BF, 40 kg N + 30 kg P_2O_5, 40 kg N + 30 kg P_2O_5 + BF, 60 kg N + 45 kg P_2O_5/ha. Pusa 23 hybrid pearlmillet and Pusa Komal variety were taken in the study.

A careful perusal of data, clearly revealed that cowpea intercropped with transplanted pearlmillet recorded significantly higher grain and stover yield as compared to cowpea intercropped with direct seeded pearlmillet during both the years of experimentation. Direct seeded transplanted pearlmillet intercropped with cowpea gave significantly higher yield but the maximum pearlmillet grain equivalent was obtained with transplanted pearlmillet intercropped with cowpea. Grain and stover yield of cowpea was greatly influenced by the methods of pearlmillet establishment. The increased productivity of grain and stover of cowpea intercropped in transplanted pearlmillet was due to favourable effect on growth and yield attributes. Similar results were also reported by Singh *et al.* (1979) and Patil *et al.* (1985).

Table 1. Effect of methods of sowing, with and without intercropping and different combinations of fertilizers and biofertilizer on plant height, effective tillers, days to 50% flowering and drymatter accumulation at harvest

Treatments	Plant height (cm)		Effective tillers per metre row length		Days to 50% flowering		Dry matter accumulation (g/plant)	
	1999	2000	1999	2000	1999	2000	1999	2000
Method of pearlmillet establishment								
Direct seeded pearlmillet in pure stand	168.56	172.50	32.77	34.91	45.00	56.67	60.31	64.05
Direct seeded pearlmillet with intercrop cowpea	175.63	181.44	31.93	34.99	46.71	58.43	60.93	66.86
Transplanted pearlmillet in pure stand	157.54	162.39	33.24	35.41	47.00	58.51	59.23	63.12
Transplanted pearlmillet with intercrop cowpea	160.67	166.83	33.21	35.08	47.00	58.43	61.23	64.94
C.D. (P=0.05)	11.62	10.69	NS	NS	NS	NS	NS	NS
Fertilizers and Biofertilizer								
Control	135.00	141.55	22.97	26.36	43.50	55.00	42.73	47.31
Biofertilizer (VAM + Azospirillum)	151.05	155.45	27.28	29.16	44.25	56.00	51.76	56.71
20 kg N + 15 kg P_2O_5	154.33	160.80	28.57	30.90	46.00	57.75	54.52	59.35
20 kg N + 15 kg P_2O_5 + BF	162.08	167.83	34.26	36.79	46.25	57.75	60.46	65.32
40 kg N + 30 kg P_2O_5	166.03	170.58	35.37	38.01	47.50	58.75	64.91	69.44
40 kg N + 30 kg P_2O_5 + BF	189.68	193.30	39.81	41.47	49.25	60.75	72.88	77.42
60 kg N + 45 kg P_2O_5	200.15	206.03	41.27	42.07	48.25	60.00	73.97	79.05
C.D. (P=0.05)	10.06	9.35	1.73	1.93	2.27	2.84	2.60	3.60

Table 2. Effect of methods of sowing with and without intercropping and different combinations of fertilizers and biofertilizer on yield attributes of pearlmillet

Treatments	Ears/m^2		Ear length (cm)		Grain weight/ earhead(g)		1000-grain weight (g)		Grain yield (q/ha)		Stover yield (q/ha)	
Method of pearlmillet establishment	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Direct seeded pearlmillet in pure stand	25.15	29.78	24.87	25.84	12.97	14.33	7.86	8.20	24.97	27.65	62.27	69.58
Direct seeded pearlmillet with intercrop cowpea	25.93	27.81	24.73	25.89	12.50	13.95	8.01	8.45	23.42	26.41	59/95	66.50
Transplanted pearlmillet in pure stand	25.76	28.52	24.36	25.16	12.66	14.11	8.02	8.59	24.53	27.01	61.04	68.14
Transplanted pearlmillet with intercrop cowpea	24.76	28.07	23.76	24.78	12.50	13.81	8.30	8.63	23.40	26.49	60.26	66.24
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizers and Biobertilizers												
Control	15.41	17.17		22.46	10.33	11.30	6.93	7.14	16.83	19.24	54.05	59.19
Biofertilizer (VAM + Azospirillum)	19.42	21.38		24.25	11.07	13.87	7.37	8.35	19.39	23.48	58.27	62.38
20 kg N + 15 kg P_2O_5	21.07	23.62		24.61	11.61	13.20	7.61	8.59	21.24	24.27	60.56	64.65
20 kg N + 15 kg P_2O_5 + BF	29.59	32.08		25.41	12.83	14.56	7.90	8.47	24.59	27.82	63.25	67.05
40 kg N + 30 kg P_2O_5	29.29	31.89		25.71	13.68	14.77	8.49	8.63	26.52	27.96	67.91	71.52
40 kg N + 30 kg P_2O_5 + BF	32.83	36.10		27.46	14.26	15.11	8.85	8.94	30.02	32.80	70.59	74.63
60 kg N + 45 kg P_2O_5	33.79	35.84		28.02	14.77	15.50	9.06	9.13	29.09	33.67	70.80	75.40
C.D. (P=0.05)	1.38	1.59		1.49	0.64	0.90	0.40	0.46	1.44	1.71	3.02	4.02

Table 3. Seed, stover yield (q/ha) of cowpea and pearlmillet equivalent of pearlmilelt + cowpea intercropping system

Treatments	Seed yield (q/ha)		Stover yield (q/ha)		Pearlmillet equivalent (q/ha)	
Method of pearlmillet establishment	1999	2000	1999	2000	1999	2000
Direct seeded pearlmillet in pure stand	24.97	27.65	62.27	69.58	24.97	27.65
Direct seeded pearlmillet with intercrop cowpea	23.42(1.37)	26.41(1.49)	59.95(4.13)	66.56(4.34)	27.63	30.26
Transplanted pearlmillet in pure stand	25.53	27.01	61.04	68.14	24.53	27.01
Transplanted pearlmillet with intercrop cowpea	23.40(1.55)	26.49(1.64)	60.26(4.36)	66.24(4.54)	28.02	30.77
SEm±	0.43(0.01)	0.50(0.02)	0.92(0.03)	1.14(0.03)	0.41	0.47
C.D. (P=0.05)	NS(0.08)	NS(0.10)	NS(0.17)	NS(0.17)	1.59	1.72
Fertilizers and Biofertilizers						
Control	16.83(1.22)	19.24(1.34)	54.24(3.85)	57.19(4.07)	18.71	20.94
Biofertilizer (VAM + Azospirilium)	19.39(1.28)	23.48(1.43)	68.27(4.11)	62.38(4.32)	21.40	25.28
20 kg N + 15 kg P_2O_5	21.24(1.38)	24.27(1.50)	69.56(4.21)	64.56(4.39)	23.35	26.20
20 kg N + 15 kg P_2O_5 + BF	24.39(1.42)	26.82(1.55)	63.25(4.30)	67.65(4.45)	26.76	28.81
40 kg N + 30 kg P_2O_5	26.52(1.51)	27.96(1.63)	67.96(4.38)	74.63(4.53)	28.81	30.07
40 kg N + 30 kg P_2O_5 + BF	20.02(1.66)	32.80(1.77)	70.59(4.42)	74.63(4.63)	32.50	35.12
60 kg N + 45 kg P_2O_5	29.09(1.69)	33.67(1.79)	70.80(4.45)	75.40(4.68)	32.50	36.03
SEm±	0.51(0.04)	0.59(0.05)	1.05(0.09)	1.40(0.10)	0.49	0.53
C.D. (P=0.05)	1.44(0.12)	1.71(0.13)	3.02(0.23)	4.02(0.29)	1.46	1.52

Note : Figure in parentheses indicate seed and stover yield of intercrop cowpea

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EFFECT OF *EUCALYPTUS GRANDIFLORA* TREES ON GROWTH AND YIELD OF RICE

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In Agroforestry system, Eucalyptus was planted with field crops, plantation crops and fruit trees. Eucalyptus trees planted on field bunds decreased the plant stand, suppressed growth, delayed flowering and maturity by 10-15 days in pigeonpea, groundnut, castor, sorghum and pearlmillet upto a distance of 10 meters (Narwal, 1994). Allelopathy plays a major role in influencing the productivity of agro ecosystems through inhibitory or stimulatory interactions. The inhibitory effects decreases the yield of field crops. Bund plantation of Eucalyptus proved harmful to field crops (Craig and Saenalo, 1988).

A field study was conducted to know the adverse effects of bund plantation of Eucalyptus on rice in vertisols at Regional Agricultural Research Station, Nandyal. The experiment was conducted in randomized block design with three replications. Seven treatments consisted of the distance from Eucalyptus i.e., 0-2, 2-4, 4-6, 6-8, 8-10, 10-12 and 12-14 m. Rice crop variety BPT 5204 was transplanted on 17th August, 2000 and harvested in 20th December, 2000. The Eucalyptus trees were of 20 years old planted at 3 m distance on either way in north-south direction. The girth of trees were one metre diameter at basal and 30 m tall. First row of rice was transplanted at a distance of 2 m from Eucalyptus trees. Observations were recorded at every 2 m interval.

Plant height was increased significant upto 2-4 m from Elucalyptus trees. Productive tillers increased from 282 m^{-2} to 343 as the distance increased from 0-2 to 12-14 m. Panicle length increased significantly from 17.45 (0-2 m) to 21.85 cm (12-14 m). Filled seeds per panicle increased from 134.7 to 201.6 as the distance increased from 0-2 to 12-14 m. However, ill filled seeds per panicle decreased from 24.4 to 5.0 as the distance increased from Eucalyptus trees. Test weight increased significantly from 15.2 to 21.25 g as the distance increased from Eucalyptus trees (Table 1).

Grain and straw yields increased significantly as the distance increased from Eucalyptus trees. The per cent reduction in grain yield was 73, 65, 44, 31 and 2 at 0-2, 2-4, 4-6, 6-8, 8-10 and 10-12 m, respectively compared to 12-14 m distance. Straw yield behaved similarly to that grain yield. The reduction in yield was higher upto 8-10 m distance from Eucalyptus trees compared to 12-14 m (Table 1). Dhillon *et al.* (1982) reported that rice planted 1, 2, 4, 5 m away from Eucalyptus trees the losses in yields were 45.8, 38.6, 38.4 and

25.9%, respectively. Growth resources, like light, temperature were adequate crop growth, hence the growth of test crop was inhibited due to allelopathic effect. Craig and Saenalo (1988) reported that bund plantation of Eucalyptus proved harmful to rice upto a distance of 15-20 m.

The study revealed that bund plantation of Eucalyptus trees adversely affect growth and yield of rice due to allelopathic effect. The reduction in yield was higher upto 8-10 m distance from Eucalyptus trees.

Table 1. Effect of Eucalyptus trees on growth and yield of rice

Distance from trees	Plant height (cm)	Productive tillers m^{-2}	Panicle length (cm)	Filled seeds per panicle	Ill filled seeds per panicle	Test weight (g)	Yield (gm^{-2})	
							Grain	Straw
0-2	60.3	282.3	17.45	134.7	24.4	15.20	151.0	163.8
2-4	70.4	285.5	18.15	142.1	21.1	16.95	199.7	214.5
4-6	71.6	295.3	18.54	162.0	11.5	18.35	314.7	321.4
6-8	73.3	312.4	18.93	184.3	7.2	19.56	386.7	393.5
8-10	76.6	330.6	21.12	196.8	6.3	20.64	480.4	490.6
10-12	78.3	342.8	21.74	200.4	5.3	21.23	550.3	571.2
12-14	78.6	343.5	21.85	201.6	5.0	21.25	562.7	571.5
S.Em±	2.0	7.4	0.52	3.6	0.8	0.34	7.2	5.5
C.D. (0.05)	6.1	22.6	1.59	11.0	2.4	1.04	22.3	16.8

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ACTIVITY AND PERSISTENCE OF PENDIMETHALIN APPLIED PRE-EMERGENCE TO SOYBEAN (*GLYCINE MAX* L. MERRILL) IN VERTISOL

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Pendimethalin is the most potent and widely used herbicide for effective weed control in soybean at 1.0 kg/ha application rate but its activity against weeds is, however, reduced in heavy soils when applied at the same rate (Kewat, 1998). Therefore, the present study was aimed at finding out most economical dose of pendimethalin and its persistence in vertisol at varying rates of application in Jabalpur.

Field investigation was carried out during kharif season of 2000 at the Research Farm of J.N. Krishi Vishwa Vidyalaya, Jabalpur. The experiment at soil was clayey in texture with 0.64% organic carbon and neutral in soil reaction (7.3 pH). The crop was fertilized with 20 kg N, 80 kg P2O5 and 20 kg K_2O/ha uniformly to all the plots. Soybean variety JS 90-41 was sown on 14th July, 2000 in rows 30 cm apart. Seven weed control treatments including a weedy check, were tested in a randomized block design and were replicated thrice. The weeds population and their dry weight were recorded at 40 DAS. Treatment wise seed yield was recorded after threshing and winnowing of crop produce obtained from each plot.

The sorghum root bioassay technique was used for detection of pendimethalin residues in the soil using profit analysis. Soil samples were collected from pendimethalin treated and untreated plots at 0, 15, 30 and 35 days after application and at the harvest of soybean (90 DAS). The soil samples, thus, obtained from each plot, were mixed thoroughly, air dried, ground with manual mortar and pestle and findly passed through at 2 mm sieve to get a homogenous soil particles. Thereafter, half kilogram of soil was drawn for each treatment by quartering techniques of which 75g soil was weighed and transferred in glass petridish having a diameter of 9 cm and three petridishes were used for each treatment. In all 90 such petridishes were used for sorghum root bioassay for detection of pendimethalin residues in soil applied at 0.5, 1.0, 1.5, 2.0 and 2.5 kg/ha including untreated control. Ten pre-germinated sorghum seeds were placed in a row across the surface of the soil in each petridish and all roots were aligned in one direction. Thereafter, each petridish was watered near to field capacity and then kept in an incubator at 26°C for 5 days till the appropriate differences in the rot length of sorghum were observed in different treatments. The root length of all the ten sorghum plants was measured treatment wise and latter on average root length was worked out for each treatment.

Besides this, sorghum root bioassay was also done by fortification of co[illegible] soil with known con[illegible] pendimethalin at 0.06. [illegible]

1.0, 1.5, 2.0 and 10 ppm. The data thus obtained, were used to develop a standard curve and the same curve was used for quantification of pendimethalin residues in unknown soil samples using profit analysis as suggested by Jacques and Harvey (1974). The half life of pendimethalin was calculated from logarithmic plots of concentration of herbicide versus time (in days) with help of equation T1/2 = 0.693/k, where K is the rate constant.

Activity on weeds

In the experimental field Phyllanthus niruri, Echinochloa crusgalli, Cynotis auxiliaries and commelina communis were the rampant weeds. Beside these, Eclipta alba, Ageratum conyzoides, Parthenium hysterophorus, Cichorium intybus, Cynodon dactylon and Cyperus rotundus also marked their presence in small numbers. The weed menace was almost zero under weed free treatment receiving two hand weeding, whereas it was maximum in weedy check (Table 1). Activity of pendimethalin at 0.5 kg/ha application rate was not well marked against most of the weeds but it was improved considerably when applied between 1.0 to 2.5 kg/ha, as the population of dominant weeds Phyllanthus niruri and Echinochloa crusgalli was curbed to a greater extent. However, other weeds like Cynotis axillaris and Commellina communis were not controlled by pendimethalin by any of the rate. Similar views were also endorsed by Kewat (1998). Different weed control treatments caused marked variation in weed biomass at 40 DAS. The highest weed biomass was recorded under weedy check plot (32.7 kg/ha) and it was reduced to nearly zero (0.71 kg/ha) in weed free plot receiving 2 hand weedings at 20 and 40 DAS. Among the herbicidal treatments, application of pendimethalin at 1.0, 1.5, 2.0 and 2.5 kg/ha arrested the weed biomass remarkably and proved superior to its lowest dose 0.5 kg/ha. These results also corroborated the findings of Tiwari *et al.* (1994).

Effect of crop

Minimum seed yield (2.77 q/ha) was recorded when weeds were allowed to grow through out the crop season (Table 2) but it was highest (15.79 q/ha) in weed free plots receivers two hand weedings at 20 and 40 DAS. Application of pendimethalin between 1.0 to 2.0 kg/ha registered the highest seed yields of soybean and these were comparable to weed free plots so for as seed yield is concerned. However, application of pendimethalin at highest rate (2.5 kg/ha) caused phytoxicity to soybean seedlings and at lowest rate (0.5 kg/ha) did not control the weeds effectively. Consequently, the seed yields were lower under former and later treatments as compared with other pendimethalin treatments. These results are in close conformity to the findings of Bhan (2001).

Economics of weed control

Weed free treatment receiving two hand weedings required the maximum investment (Rs. 4400/ha) for the control of weeds, while expenditure incurred under pendimethalin at different rates ranged between Rs. 900 to Rs. 3915/ha, indicating that control of weeds through hand weedings was more expensive than use of the pendimethalin in soybean. Though maximum gross monitory return was obtained under weed free treatment but highest net return (Rs. 4003/ha) and benefit

Table 1. Effect of weed control treatments on the density of major weeds and dry matter at 40 days after sowing

Herbicide	Rate kg/ha	Time of Application	Weed Density (m^{-2})				Weed Dry* Weight (kg/ha)
			Phyllanthus niruri	Enchinochloa cursgalli	Cynotis axillaris	Commelina communis	
Pendimethalin	0.5	PE	99	11	36	34	27.17
Pendimethalin	1.0	PE	91	4	35	35	20.65
Pendimethalin	1.5	PE	87	3	33	35	17.53
Pendimethalin	2.0	PE	57	2	33	36	17.33
Pendimethalin	2.5	PE	55	2	32	36	16.95
Unweeded check	-		182	75	3	34	32.7
Weed free check	2HW	20 & 40 DAS	-	-	-	-	0.71
CD (P=0.05)							9.43

* = Data subjected to $\sqrt{X} + 0.05$ transformation, HW = Hand weeding

Table 2. Effect of pendimethalin treatments on seed yield and economics of soybean

Herbicide	Rate (kg/ha)	Seed yield (q/ha)	Comon Cost (Rs./ha)	Cost of weed control (Rs./ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit cost ratio
Pendimethalin	0.5	9.86	6783	900	7683	9513	1830	1.24
Pendimethalin	1.0	11.89	6783	1665	8448	11442	2994	1.35
Pendimethalin	1.5	13.78	6783	2430	9213	13216	4003	1.43
Pendimethalin	2.0	12.42	6783	3150	9933	11878	1945	1.20
Pendimethalin	2.5	8.93	6783	3915	10698	8526	-2172	0.80
Unweeded check	-	2.77	6783	-	6783	2678	-4105	0.39
Weed free check	2HW	15.79	6783	4400	11183	14931	3748	1.34
CD (P=0.05)		5.21	-	-	-	-	-	-

Selling price of soybean seed : Rs. 900/q. Cost of Stomp : Rs. 450/1. Gross return includes monetary value of seed and straw

cost ratio (1.43) were fetched when pendimethalin was applied at 1.5 kg/ha, closely followed by 1.0 kg/ha being comparable to weed free plots. Kurmawanshi *et al.* (1995) also endorsed the similar views. However, it is remarkable to note that there was loss of Rs. 4105 and 2172/ha either when weeds were not controlled at all or controlled with highest dose of pendimethalin, respectively.

Persistene of pendimethalin

The mean values of pendimethalin averaged over replications show that dissipation of pendimethalin was more acute (64%) during first 30 days when applied at the lowest rate (0.5 kg/ha), whereas it was less 30-24% with corresponding increase in application rates from 1.0 to 2.5 kg/ha (Table 3). This is because of restricted activities of microbes due to presence of pendimethalin residues in lethol concentration in the soil. After one and half month of time 86-76% pendimethalin was lost from the soil between 0.5 to 1.5 application rates but it was 52-32 per cent only when applied at higher rates 2.5 to 2.0 kg/ha respectively. At harvest (90 DAS) only 3-15% residue of the original value was persisted in the soil when applied between 0.5 to 1.5 kg/ha, but it was identically more (38-43%) with higher rates of application (2.0 to 2.5 kg/ha), suggesting that it is rather safe to apply pendimethalin between 1.0 to 1.5 kg/ha for effective control of weeds without any phytoxic effect on soybean crop. These results postulated the findings of Kewat et al. (2001).

The dissipation of pendimethalin did not follow the first order rate kinetics at any rate of application (Fig. 1), indicating that the loss of pendimethalin in the soil was not proportional to time. The half-life of pendimethalin was around 23 days when applied between 0.5 to 1.5 kg/ha but it increased to 33-43 days when applied at 2.0 and 2.5 kg/ha respectively. Diwan et al. (1999) found half life of pendimethalin between 28031 days at 0.75, 1.0, 1.25, 1.50 and 2.0 kg/ha application rates.

Table 3. Pendimethalin residues (µg/g) in soil at different interval and its half life

Days after application	Pendimethalin residues (µg/g) at different rates of application				
	0.5 kg/ha	1.0 kg/ha	1.5 kg/ha	2.0 kg/ha	2.5 kg/ha
0	1.24 (00.0)	1.25 (00.0)	1.25 (00.0)	1.29 (00.0)	1.31 (00.0)
15	1.97 (21.7)	1.15 (08.0)	1.17 (07.14)	1.20 (07.0)	1.22 (06.9)
30	0.45 (63.7)	0.87 (30.4)	0.90 (28.6)	0.95 (26.3)	1.00 (23.7)
45	0.17 (86.3)	0.25 (80.0)	0.34 (73.0)	0.62 (52.0)	0.82 (32.4)
90	0.04 (96.8)	0.11 (91.2)	0.19 (85.0)	0.49 (62.0)	0.69 (52.7)
Half life (in days)	23.2	23.2	23.2	33.5	43.0

Figures in parenthesis indicates per cent dissipation

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RESPONSE OF NEW CHICKPEA GENOTYPES TO DIFFERENT DATES OF SOWING UNDER IRRIGATED CONDITIONS

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In Haryana chickpea occupies 4.3 per cent of total area under pulses and contributes about 4.5 per cent of total production of pulses in the country (Anonymous, 2000). Evolution of new genotypes is a continuous process and it becomes essential to test the performance of newly developed genotype to different sowing dates to exploit its potential. Taking this into consideration the present investigation was carried out.

A field experiment was conducted during winter season of 2000-2001 at Research Farm of CCS Haryana Agricultural University, Hisar. The soil of the experimental plot was sandy loam in texture having pH 7.8, available nitrogen, phosphorus and potash 106, 14.2 and 522 kg ha-1, respectively. Treatment consisted of five dates of sowing viz., October 20, November 5, November 20, December 5 and December 20 and four genotypes viz., C 235, HC 1, HC 3 and H 92-67. The experiment was laid out in split plot design replicated thrice with sowing dates in main plots and genotypes in sub-plots. The crop was sown at 30 cm spacing. A uniform dose of fertilizer in the form of DAP @ 87.5 kg ha-1 was drilled before sowing. One irrigation at pre-flowering stage was applied.

Effect of sowing dates

Plant height and dry matter of chickpea reduced significantly with the delay in sowing from November 5 and October 20, respectively. More plant height of early sown crop (October) was also reported by Saini and Faroda (1997), respectively. The reduction in plant height and dry matter in late planting might be attributed to the progressive decrease in temperature with the delay in sowing which delayed the germination and ultimately curtailed the total growth period. No significant difference in grain and straw yield was observed between October 20 and November 5 sowings. The decrease in grain yield was 37.48, 46.73 and 50.63 per cent in November 20, December 5 and December 20 sowing, respectively as compared with November 5 sowing (Table 1). Increase in grain yield with November 5 sown crop was associated with higher number of pods per plant, more number of grains per pod and bolder grains (Table 1). Tripathi and Singh (1985) also obtained highest grain yield from November 5 sowing as compared with early and delayed sowings. Sowing dates did not influenced the harvest index of chickpea.

Effect of genotypes

Among genotypes the plants of H 92-67 were found significantly taller than other genotypes, whereas, dry matter of HC 3 was found significantly higher due to more number of branches and bushy plant architect. HC 1 produced significantly higher grain as well as straw yield as compared with other genotypes which might be attributed to the higher number of pods per plant. Grain and straw yield of C 235 and HC 3 was found at par with each other which might be due to non-significant differences in number of pods per plant (Table 1). Varietal variation in yield and yield attributes has also been reported by Tiwari *et al.* (1996).

Table 1. Yield attributes and yield of chickpea genotypes as influenced by sowing dates

Treatment	Plant height (cm)	Dry matter/ plant (g)	Branches per plant (No.)	Pods per plant (No.)	Grains per pod (No.)	100 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Sowing dates									
October 20	56.67	33.34	3.77	70.58	1.11	18.17	2143	5671	77.4
November 5	58.31	31.90	4.11	73.43	1.52	17.9	2161	5616	27.8
November 20	53.60	20.43	3.75	42.56	1.33	16.35	1351	3428	28.3
December 5	44.80	14.67	3.54	36.44	1.21	15.64	1151	3020	27.6
December 20	41.55	10.41	3.39	31.93	0.97	14.39	1067	2847	27.1
C.D. at 5%	1.53	1.06	0.50	2.01	0.06	1.10	99	2.53	NS
Genotypes									
C 235	44.93	18.52	3.62	47.95	1.45	11.64	1608	4106	28.2
HC I	49.86	23.65	3.32	55.35	1.26	14.15	1721	4496	27.7
HC 3	53.70	25.60	3.94	47.03	1.07	24.63	1548	4153	27.1
H 92-67	55.45	20.79	3.89	54.12	1.16	15.79	1421	3711	27.6
C.D. at 5%	1.16	0.89	0.26	1.80	0.05	0.94	97	218	NS

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